Name: _____

Data Science

Fall 2024 Student Workbook - CODAP Edition

Workbook v0.9-beta

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Pioneers in Computing and Mathematics

The pioneers pictured below are featured in our Computing Needs All Voices lesson. To learn more about them and their contributions, visit https://bit.ly/bootstrap-pioneers.

We are in the process of expanding our collection of pioneers. If there's someone else whose work inspires you, please let us know at https://bit.ly/pioneer-suggestion.

Notice and Wonder

Write down what you Notice and Wonder from the What Most Schools Don't Teach video.
"Notices" should be statements, not questions. What stood out to you? What do you remember? "Wonders" are questions.

What do you Notice?	What do you Wonder?

Windows and Mirrors

Think about the images and stories you've just encountered. Identify something(s) that served as a mirror for you, connecting you with your own identity and experience of the world. Write about who or what you connected with and why.

Identify something(s) from the film or the posters that served as a window for you, giving you insight into other people's experiences or expanding your thinking in some way.

Reflection: Problem Solving Advantages of Diverse Teams

This reflection is designed to follow reading LA Times Perspective: A solution to tech's lingering diversity problem? Try thinking about ketchup

1) The author argues that tech companies with diverse teams have an advantage. Why?

2) What suggestions did the article offer for tech companies looking to diversify their teams?

3) What is one thing of interest to you in the author's bio?

4) Think of a time when you had an idea that felt "out of the box". Did you share your idea? Why or why not?

5) Can you think of a time when someone else had a strategy or idea that you would never have thought of, but was interesting to you and/or pushed your thinking to a new level?

6) Based on your experience of exceptions to mainstream assumptions, propose another pair of questions that could be used in place of "Where do you keep your ketchup?" and "What would you reach for instead?"

Introduction to Computational Data Science

Many important questions ("What's the best restaurant in town?", "Is this law good for citizens?", etc.) are answered with *data*.
Data Scientists try to answer these questions by writing *programs that ask questions about data*.

Data of all types can be organized into **Tables**.

- Every Table has a **header row** and some number of **data rows**.
- **Quantitative data** is numeric and measures *an amount*, such as a person's height, a score on a test, distance, etc. A list of quantitative data can be ordered from smallest to largest.
- **Categorical data** is data that specifies *qualities*, such as sex, eye color, country of origin, etc. Categorical data is not subject to the laws of arithmetic — for example, we cannot take the "average" of a list of colors.

Categorical or Quantitative?

- **Quantitative data** measures an *amount* and can be ordered from smallest to largest.
- **Categorical data** specifies *qualities* and is not subject to the laws of arithmetic — for example, we cannot take the "average" of a list of colors.

  Note: Numbers can sometimes be categorical rather than quantitative!

For each piece of data below, circle whether it is **Categorical** or **Quantitative**.

1)	Hair color	categorical	quantitative
2)	Age	categorical	quantitative
3)	ZIP Code	categorical	quantitative
4)	Date	categorical	quantitative
5)	Height	categorical	quantitative
6)	Sex	categorical	quantitative
7)	Street Name	categorical	quantitative

For each question, circle whether it will be answered by **Categorical** or **Quantitative** data.

8)	We'd like to find out the average price of cars in a lot.	categorical	quantitative
9)	We'd like to find out the most popular color for cars.	categorical	quantitative
10)	We'd like to find out which puppy is the youngest.	categorical	quantitative
11)	We'd like to find out which cats have been fixed.	categorical	quantitative
12)	We want to know which people have a ZIP code of 02907.	categorical	quantitative

★ We decide to sort the animals in *ascending order* (smallest-to-largest) by `age`. Then we sort the table in *alphabetical order* (A-to-Z) by `name`.

Does that mean `name` is a quantitative column? Why or why not? _____

_____

_____

_____

Questions and Column Descriptions

1) Take some time to look through the Animals Dataset. What stands out to you? Which animals are interesting? What patterns do you notice? Put your observations in the **Notice** column below.

2) Do any of these observations make you wonder? If so, write your question next to the observation in the **Wonder** column. If not, think of another question to write down.

Notice	Wonder	Answered by this dataset?
I notice that *Kujo took a long time to be adopted*	*Is it because he was so big?*	*Yes No*
I notice that		*Yes No*
I notice that		*Yes No*
I notice that		*Yes No*
I notice that		*Yes No*
I notice that		*Yes No*
I notice that		*Yes No*

Describe the table, and two of the columns, by filling in the blanks below.

1. This dataset is about _____; it contains _____ data rows.
2. Some of the columns are:

   a. _____ (column name), which contains _____ (*categorical or quantitative*) data. Some example values are:

   _____.

   b. _____ (column name), which contains _____ (*categorical or quantitative*) data. Some example values are:

   _____.

What Questions Can You Answer with the Given Data?

The following is a dataset of a bicycle rider's training rides.

date	miles	time (w/stops)	weather	average speed	max speed
04/10/2018	10	44	"cloudy"	13	30
05/30/2018	15	66	"sunny"	13.5	22
06/12/2018	12	61	"rainy"	11.2	25
07/04/2018	24	103	"sunny"	14	26
07/12/2018	24	120	"windy"	12.5	26

1) Decide whether each questions below *can* or *cannot* be answered with the given data and circle your selection.

Question	Answered by this dataset?	
How many miles did the cyclist ride June 12th?	*Yes*	*No*
What tire pressure produces the highest average speed?	*Yes*	*No*
What is the average time it takes this cyclist to ride 1 mi?	*Yes*	*No*
Does this cyclist ride slower when it is rainy?	*Yes*	*No*
Does this cyclist ride faster when they are late to an appointment?	*Yes*	*No*
How many miles has the cyclist ridden in total as part of their training?	*Yes*	*No*

2) In the space provided below each question, explain *how* you could answer the question using the data or *why you cannot* answer the question.

★ Are there any questions that you could find the answers to more than one way?

Opening Questions

Sports

- Who is the best quarterback of all time?
- Are baseball pitchers throwing harder than ever?
- How much more do male soccer players earn than females?
- How common is it for former Olympic athletes to become coaches?
- How much does an extra inch of height help a basketball player?

Pop Culture

- What percentage of people have seen the movie that won last year's Best Picture Award?
- Who tends to be more popular: bands or solo singers?
- Are younger actors paid more than older actors?
- Are movies with female leads as profitable as movies with male leads?
- Does winning a Grammy increase sales?

Politics

- Is "Stop and Frisk" a racist policy?
- Do Republican politicians tend to come from different states than Democratic ones?
- Do people in countries that have universal healthcare live longer than people in countries that don't?
- Was press coverage slanted for or against a particular candidate?

Education

- Do small schools perform better than large ones?
- Which has a stronger correlation with student achievement: race or wealth?
- Do bilingual classes result in better outcomes for ESL/ELL students?
- How does quality of education differ in various regions of the United States?

Exploring CODAP

CODAP is a web-based data science tool that runs in your web browser.

Data Types

CODAP utilizes different ***data types***, including Numbers, Strings, and Booleans.

- Numbers are values like `1`, `0.4`, `1/3`, and `-8261.003`.
  - Numbers are *usually* used for quantitative data and other values are *usually* used as categorical data.
- Strings are values like `"Emma"`, `"Rosanna"`, `"Jen and Ed"`, or even `"08/28/1980"`.
  - All strings *must* be surrounded in quotation marks.

All values evaluate to themselves. The program `42` will evaluate to `42`, and the String `"Hello"` will evaluate to `"Hello"`.

Operators

Operators (like `+`, `-`, `<`, etc.) work the same way that they do in math.

- Operators are written between values, for example: `4 + 2`.

Expressions

Expressions work the same way that they do in math. Numeric expressions can be *evaluated*.

- The following are all examples of expressions: `sqrt(16)`, `sqrt(Weight)`, `m+5`, and `9+17`.

CODAP Exploration

This page will help you familiarize yourself with some of CODAP's features. Check off each item once you have completed it. Feel free to experiment and try things out! Make sure you're logged into the Animals Starter File in CODAP before beginning.

Tables in CODAP

1) A table of data is shown here, with the title at the top of the table. What is the title? _____

2) Move the table to a different location on the screen, then minimize the table (hints: Hovering your mouse over the title. What appears?).

3) Re-expand the minimized table, then add a row - also called a *case* - to the table. (Hint: Click any of the Index numbers in the left-most column. Look at the menu that appears.) Can you delete that same row? (Note: CODAP will not let you delete an *empty* case.)

4) Move the `Age` column so that it is between `Fixed` and `Legs`. Click on `Age` and choose "Sort Ascending (A→Z, 0→9)" from the drop-down menu that appears.

5) Now try "Sort Descending". How many animals have names that begin with S? _____

6) Delete a column of the table. (Columns are sometimes called *attributes*.)

7) Use the "Undo" button in the upper right to get your column back. Do the keyboard shortcuts for Redo (`Ctrl–Y` on PC, `Cmd–Opt–Z` on Mac) and Undo (`Ctrl–Z` on PC, `Cmd–Z` on Mac) work in CODAP? _____

8) Close the table. Get it back either by opening the drop-down menu that appears when you click on "Tables" in the upper left.

9) Create a new attribute. Is the column populated (filled in) or empty? _____

10) Name your new attribute. What name did you choose? _____

Graphs in CODAP

11) Click on the "Graph" icon in the upper left-hand corner of the screen. *Note: When you first make a graph, the points are randomly positioned!*

12) How many dots appeared on the graph? (Hint: How many rows - or *cases* - are on the table?) _____

13) Click on a dot. What happens? _____

14) Can you figure out a way to make *different* information appear when you click on a dot? (Hint: You may need to move a column!)

15) Drag an attribute (like `Weight`, `Name`, or `Sex`) to one of the graph's axes - or use the drop-down menu that appears when you click on an axis. Can you make the graph show *two* attributes?

16) Double click on the background of your graph. What happens? _____

17) Click on the "Rescale" icon (it looks like four arrows pointing in four different directions) to zoom back out and display all data again.

18) Once a graph shows two attributes, can you change it back to a graph with one attribute?

19) Click and drag any attribute name from the top of any column in the dataset to the center of the graph. When the graph region turns yellow, release the mouse. What happened? _____

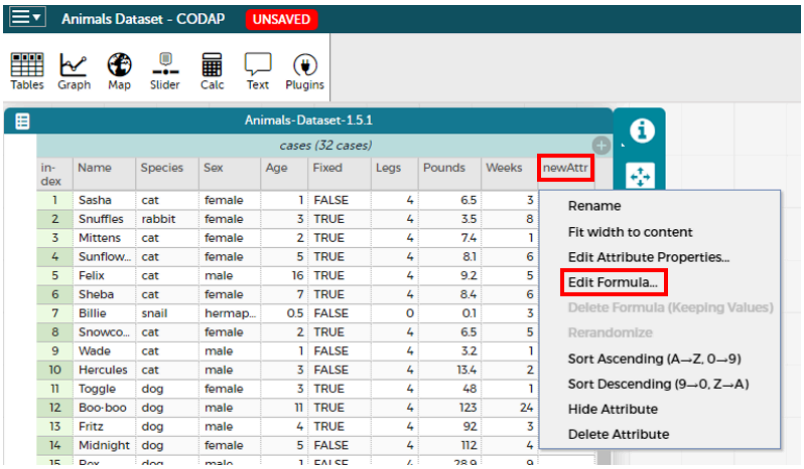
Matching

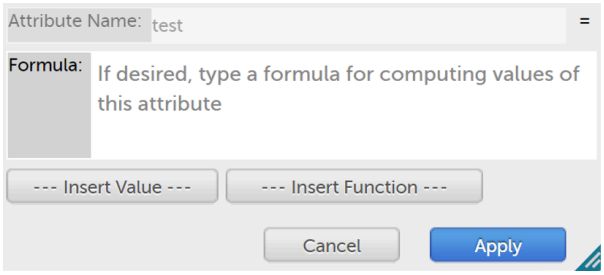
Complete the matching activity below to review what you discovered about graphs and tables in CODAP.

In order to…			I need to…
delete a table column	**20**	**A**	click on an orange point
move a table	**21**	**B**	mouse over the title bar until a – button appears in the upper right-hand corner
minimize a table	**22**	**C**	select the attribute; from the drop-down menu that appears, select "Delete Attribute"
create a new table column	**23**	**D**	click the "Graph" icon in the upper left-hand corner of the screen
create a graph of randomly configured points	**24**	**E**	mouse over the title bar until the cursor turns into a hand
identify information about a specific point	**25**	**F**	make sure the table is selected, then click the grey plus sign

Strings

- For each of three sections below, refer Animals Starter File.
- In order to follow the directives, you must first create a new column that appears after you select the table.
- Next, click on the attribute name (`newAttr`) and select `Edit Formula`.
- **In order to follow the directives below, you must type text into the "Edit Formula" box.**





Task 1: "Hello, my name is"

The shelter wants to put a name tag in front of each animal's cage so visitors can learn their names. One shelter employee suggests populating all the rows of an entire column with "Hello, my name is" to create enough tags for all of the animals. After printing the tags, shelter employees will write in each animal's name.

1) Click on `newAttr`. Select `Edit Formula`. Type `Hello, my name is` into the formula box that appears, then select `Apply`. What error message appears in all the rows of this column? _____

2) Click `new Attr` again, then select `Edit Formula`. This time, type `"Hello, my name is"` (*with quotation marks!*) into the formula box. What happens? _____

3) Try typing `Hello, my name is` with the opening quote, but without the closing quote, and select `Apply`. What do you think a "syntax error" is? _____

4) A string is any value that is entered within _____ . _____

Task 2: "Hello, my name is Sasha" ... "Hello, my name is Snuffles" ...

The employee who proposed this solution is happy with it... but you wonder: Wouldn't it be cool if CODAP could input each animal's unique name after "Hello, my name is"? Then, you wouldn't need to handwrite in all those animals' names.

5) Access the formula box again. Try typing in `"Hello, my name is Name"`. Did you get the result you want? _____

6) This time, try typing the `"Hello, my name is " + Name`, being sure to leave `+ Name` out of the string. What happens? _____

_____

7) Do you get the same result if you use `"Hello, my name is " + name`? Does CODAP care about capitalization of attribute names?

_____

8) Now you're feeling like you can create all kinds of nametags! Edit the formula box to create tags for all of the animals resembling this one: "Hello, my name is Felix. I am a 16 year old cat who weighs 9.2 pounds."

Numbers

Task 3: Playing with Pounds

As an employee of the shelter, you want each of these animals to be adopted! You wonder if visitors to the shelter might prefer to receive each animal's weight in kilograms, or maybe rounded to the nearest whole number.

1) But first… let's make sure we understand how numbers work in CODAP. Create a new column, then enter the specified information into the formula box. (You can delete what's in the formula box once you've observed the output.)

- Type `42` (no quotes). *Click Apply.*
- Type a fraction. *Click Apply.*
- Type a decimal. *Click Apply.*
- Type an integer. *Click Apply.*
- Enter some expressions that include operators, such as `5 * (8 + 2)`. *Click Apply.*

Does anything surprise you about how numbers behave in CODAP? Does CODAP know the order of operations? _____

_____

2) Create a new column. Name it `Kilograms`. Note that to convert pounds to kilograms, we divide by 2.205. What will you enter in the formula box to populate this column with each animal's weight in kilograms? _____

_____

3) Create another new column. Name it `Rounded Kilograms`. Here, you will use the function `round`, which returns the value of its input, rounded. Enter `round(Kilograms)` in the formula box. What place value did `round` round to? _____

4) Enter `round(Kilograms, 1)`, then change it to `round(Kilograms, 2)`. What does the round function do with that second - optional - argument?"

_____

_____

5) Click on `Kilograms`. From the drop-down menu that appears, select `Edit Attribute Properties`. Try changing the precision. How is changing precision different from rounding? _____

_____

Task 4: You're the official CODAP expert at the shelter!

You've been so successful answering people's CODAP questions that now *everyone* is ocming to you for help! You decide to spend some time playing around with more of the available functions, so you can help anyone who asks.

6) Enter `sqrt(16)` into the `Edit Formula` box. How many arguments does `sqrt` expect? _____

7) What type of argument does the function `sqrt` expect? _____
Number? String?

8) What type of output does `sqrt` produce? _____
Number? String?

9) Put a check-mark next to expression below that will successfully populate a column. If you're not sure, try them out in Animals Starter File.

`sqrt(Weight)`	`sqrt(Legs)`	`sqrt(Name)`

10) Why will some of these expressions work and some generate errors? _____

_____

Dot Plots and Bar Charts

Displaying Categorical Variables

- With a table open in CODAP, select the "graph" icon to produce a scatter plot of *randomly distributed* data points.
- Drag attributes/columns to the axes (or select from a drop-down menu of attributes/columns by clicking the axes) to organize the data so that it is no longer randomly distributed.
- Once the data is organized, manipulate it further by selecting the graph menu icons:
  - **the ruler icon** provides options for calculating statistics such as mean, median, and standard deviation
  - for datasets with two variables, clicking the ruler icon will provide *additional* statistical computations (such as a least squares line or regression line)
  - the **bar graph icon** allows new configurations of the data. Select this option to group data points into bins or create a bar for each point. If the data is numeric, clicking on the bar graph icon a second time (for instance, after data is grouped into bins) allows the creation of a histogram (by fusing the dots into bars).

Exploring other Displays

Data Scientists use **data displays** to visualize information. You've probably seen some of these charts, graphs and plots yourselves! When it comes to displaying ***Categorical Data***, we often rely on **dot plots** and ***bar charts***. (Pie charts display categorical data, too, but CODAP doesn't offer them largely because many find them challenging to read.)

When we want to create a data display in CODAP, it is important to consider the following: Which attributes on which axes? What type of data? What configuration?

Bar charts show the *count or percentage* of rows in each category.

- Bar charts provide a visual representation of the frequency of values in a categorical column.
- Bar charts have a bar for every category in a column.
- The more rows in a category, the taller the bar.
- Bars in a bar chart can be show in *any order* , without changing the meaning of the chart. However, bars are usually shown in some sensible order (bars for the number of orders for different t-shirt sizes might be presented in order of smallest to largest shirt).

Dot Plots and Bar Charts in CODAP

Open the Animals Starter File. First, create a graph of randomly generated points by selecting the `Graph` icon, and then respond to the following prompts.

Create Displays

1) Select the y-axis on your graph (where it says "Click here"). On the drop-down menu that appears, select `Fixed`. (*If you prefer, you may also drag the attribute name from the table to the y-axis.*) What do you notice?

2) Now select the x-axis on your graph and select `Fixed`. How does the graph change?

3) Select the `configuration` icon (which looks like a bar graph) to the right of the data display. Select `Fuse Dots into Bars`

4) Click the `ruler` icon to test `count` and `percentage`. What happens?

5) Now, make a bar chart showing how many animals there are of each species by changing the variable on the x-axis to `species`. How can reconfigure the bar chart as a dot plot?

Numeric vs. Categorical Displays

6) Create a graph with `Weeks` on the x-axis. What intervals do you see on the x-axis?

7) Now, click on `Weeks` so that a drop-down menu appears. From this drop-down menu, choose `Treat as Categorical`. How did the numbers on the x-axis change? (*Look closely!*)

8) Why do you think CODAP produced a graph with intervals on the x-axis that are *not* evenly spaced?

9) As you've discovered, CODAP can view `Age` as numeric or categorical. In which mode can we `Fuse dots into bars`? Think about what sort of data bar graphs display.

Introducing Displays for Subgroups

This page is designed to be used with the Expanded Animals Starter File.

Part A

1) How many tarantulas are male? _____
Hint: Sort the table by `species`*!*

2) How many tarantulas are female? _____

3) Would you imagine that the distribution of male and female animals will be similar for every species at the shelter? Why or why not?

_____

_____

Part B

Sometimes we want to compare *sub-groups across groups* . In this example, we want to compare the distribution of sexes across each species. Fortunately, CODAP allows us to build a variety of displays where we specify both a group and a subgroup.

To create a **stacked bar chart** …	To make a **multi bar chart** …
• create a graph of randomly distributed points • drag the *group* to an axis • drag the *sub-group* to the center of the display • from the Configuration menu, select "Fuse Dots into Bars" • from the Configuration menu, select "Percent" as the scale.	• create a graph of randomly distributed points • drag the *sub-group* to an axis • drag the *group* to the + in the upper left-hand corner of the graph • from the Configuration menu, select "Fuse Dots into Bars" • to the right of the graph, locate and click the "Rescale Display" button (it looks like four arrows pointing in different directions) until you can see all of the data.

4) Make a stacked bar chart showing the distribution of sexes across species in our shelter.

5) Make a multi bar chart showing the distribution of sexes across species in our shelter.

6) What do you notice? _____

_____

_____

7) What do you wonder? _____

_____

8) Which display would be most efficient for answering the question: "What percentage of cats are female?" Why?

_____

9) Which display would be most efficient for answering the question: "Are there more cats or dogs?" Why?

_____

10) Write a question of your own that involves comparing subgroups across groups. _____

_____

Which display would be most efficient for answering your question? _____ Make the display.

11) Write a different question that would be more efficient to answer with the other kind of display. _____

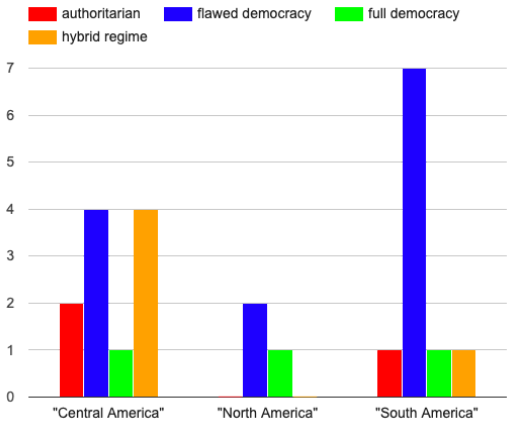
_____

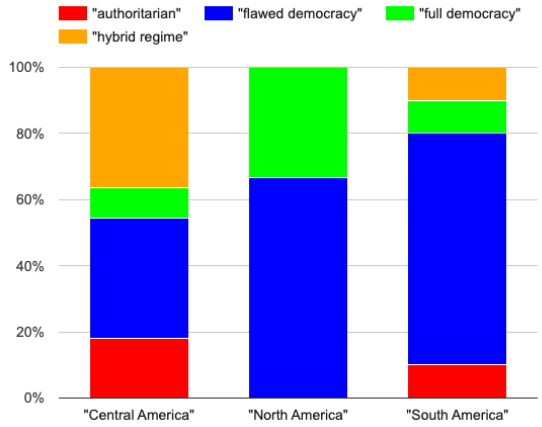
Multi Bar & Stacked Bar Charts - Notice and Wonder

The displays on the left are called **multi bar charts**.

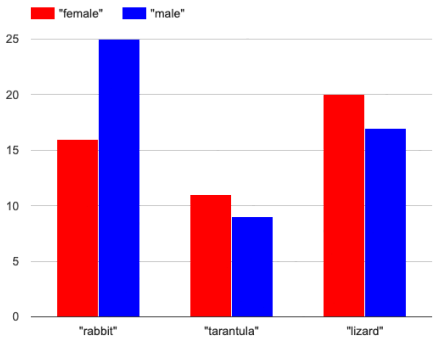
The displays on the right are called **stacked barcharts**.

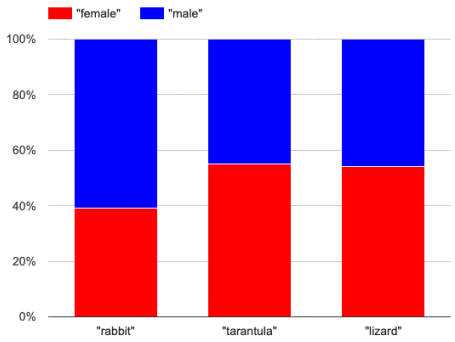
Political Structure of Countries in the Americas





Distribution of sexes across Cats, Dogs and Rabbits





What do you Notice?	What do you Wonder?

1) Is it possible that the same data was used for the multi bar charts as for the stacked bar charts? How do you know?

2) Write a question that it would be easiest to answer by looking at one of the multi bar charts.

3) Write a question that it would be easiest to answer by looking at one of the stacked bar charts.

Practice Plotting

Use the Animals Starter File to create the following displays in CODAP. First, fill in the blanks and check all boxes that apply. Next, predict and sketch what the display will look like. Then, create the display in CODAP. We've started the first one for you!

1) A histogram of the number of `pounds` that animals weigh.

Column / Attribute	Type of Data	Configuration
pounds [column used as x-axis] n/a [column used as y-axis]	✓ Numeric ❑ Categorical	❑ Points ✓ Fuse dots into bars ❑ Bar for each point ✓ Group into bins ❑ No need to make a selection

Sketch the chart below:	What do you think the data display tells us?

2) A dot plot showing the `sex` of animals from the shelter.

Column / Attribute	Type of Data	Configuration
[column used as x-axis] [column used as y-axis]	❑ Numeric ❑ Categorical	❑ Points ❑ Fuse dots into bars ❑ Bar for each point ❑ Group into bins ❑ No need to make a selection

Sketch the chart below:	What do you think the display tells us?

Practice Plotting (2)

Use the Animals Starter File to create the following displays in CODAP. First, fill in the blanks and check all boxes that apply. Next, predict and sketch what the display will look like. Then, create the display in CODAP.

1) A bar chart showing the `species` of animals from the shelter.

Column / Attribute	Type of Data	Configuration
_____ [column used as x-axis] _____ [column used as y-axis]	❏ Numeric ❏ Categorical	❏ Points ❏ Fuse dots into bars ❏ Bar for each point ❏ Group into bins ❏ No need to make a selection

Sketch the chart below:	What do you think the display tells us?

2) A scatter-plot, using the animals `name` as the labels, `age` as the x-axis, and `pounds` as the y-axis, for all the animals from the shelter. *Note: The* `Measure` *menu has lots of options! On this page, we've included the two options that* ***create new displays*** .

Column / Attribute	Type of Data	Measure
_____ [column used as x-axis] _____ [column used as y-axis] _____ [(optional) column used for labels]	❏ Numeric ❏ Categorical	❏ Box plot ❏ Least squares line ❏ No need to make a selection

Sketch the chart below:	What do you think the data display tells us?

Practice Plotting (3)

Use the Animals Starter File to create the following displays in CODAP. First, fill in the blanks and check all boxes that apply. Then, predict and draw what you think the display will look like. Finally, create the display in CODAP.

1) A boxplot, using `Pounds` as the x-axis, for all the animals from the shelter. *Note: The* `Measure` *menu has lots of options! On this page, we've included the two options that* ***create new displays*** .

Column / Attribute	Type of Data	Measure
_____ [column used as x-axis] _____ [column used as y-axis]	❏ Numeric ❏ Categorical	❏ Box plot ❏ Least squares line ❏ No need to make a selection

Sketch the chart below:	What do you think the data display tells us?

2) (Challenge) A least squares line (also sometimes called a regression line), using the animals `species` as the labels, `pounds` as the x-axis, and `weeks` as the y-axis, for all the animals from the shelter.

Column / Attribute	Type of Data	Measure
_____ [column used as x-axis] _____ [column used as y-axis] _____ [(optional) column used for labels]	❏ Numeric ❏ Categorical	❏ Box plot ❏ Least squares line ❏ No need to make a selection

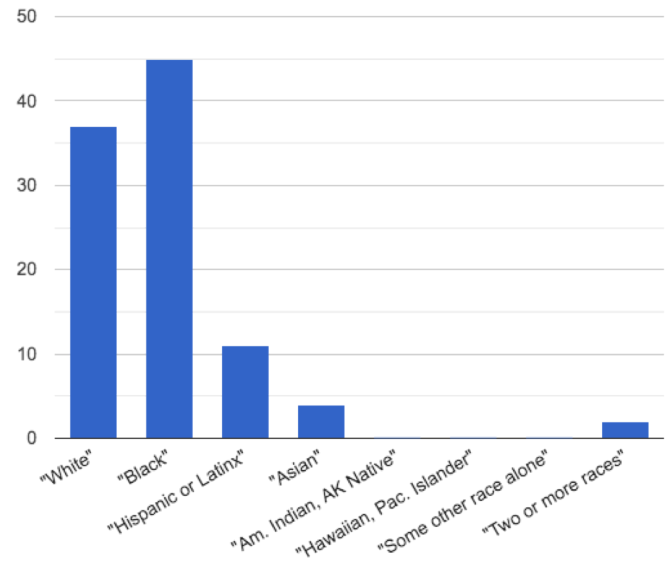
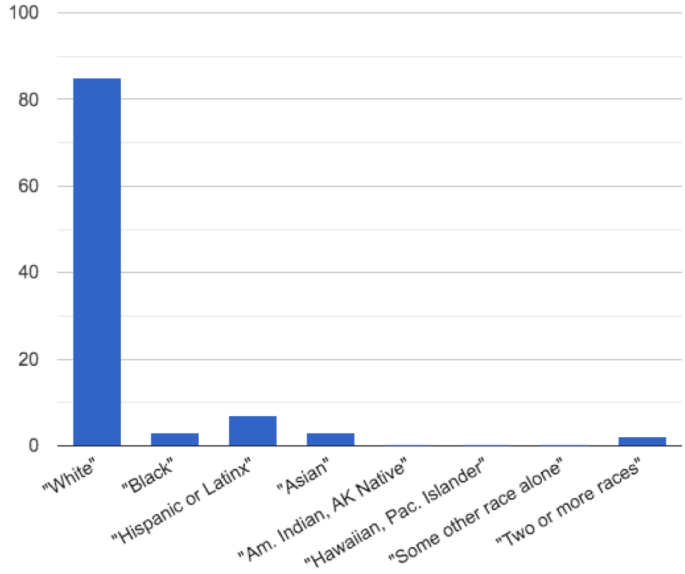
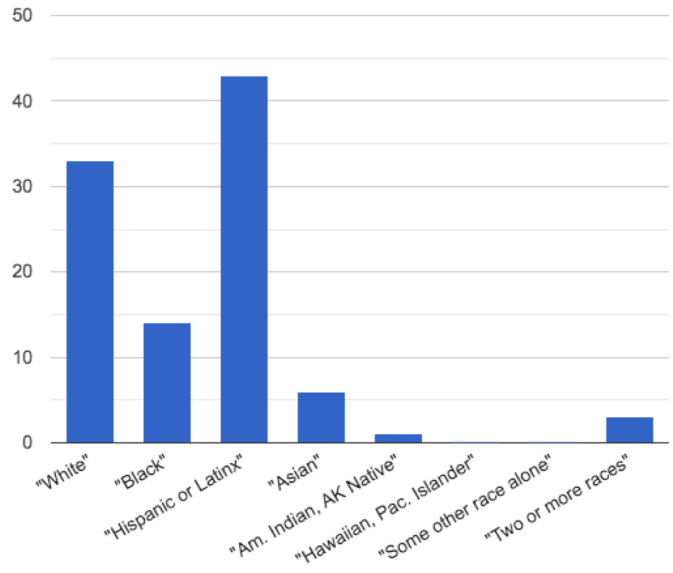
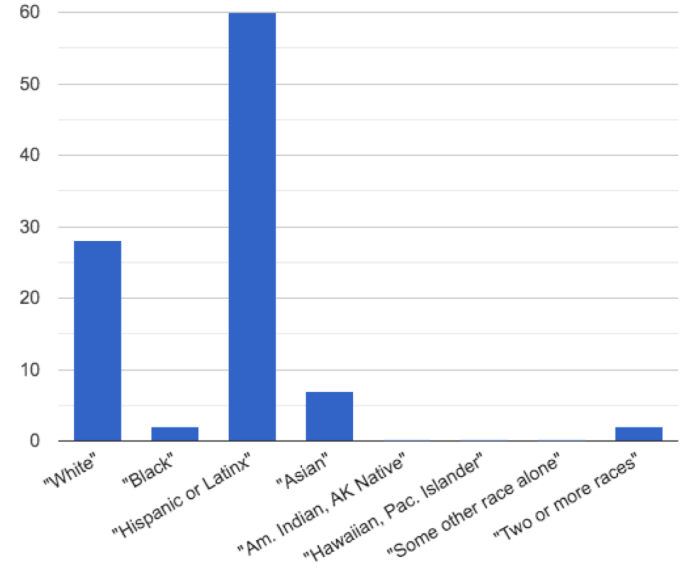
Sketch the chart below:	What do you think the data display tells us?

Data Displays Organizer

Put a check mark to indicate whether each chart listed below displays *1 variable or 2 variables*, and whether it displays data that is *categorical or numeric*. In the notes column, add any relevant reminders to yourself about when to use each display. You will want to revisit and add additional notes to this page as you learn more about each of the displays.

Display	How many variables? What type?	Notes *(How do I create the display? What does it tell me?)*
dot plot	How many variables? ❑ 1 ❑ 2 What type? ❑ Numeric ❑ Categorical	
bar chart	How many variables? ❑ 1 ❑ 2 What type? ❑ Numeric ❑ Categorical	
histogram	How many variables? ❑ 1 ❑ 2 What type? ❑ Numeric ❑ Categorical	
scatter plot	How many variables? ❑ 1 ❑ 2 What type? ❑ Numeric ❑ Categorical	
box plot	How many variables? ❑ 1 ❑ 2 What type? ❑ Numeric ❑ Categorical	
least squares line	How many variables? ❑ 1 ❑ 2 What type? ❑ Numeric ❑ Categorical	

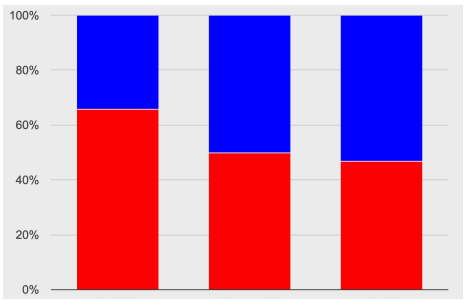
Bar Chart - Notice and Wonder

Washington, D.C. Public Schools	West Warwick Schools, RI
	
Providence Schools, RI	**Oxnard Union HS District, CA**
	

What do you Notice?	What do you Wonder?

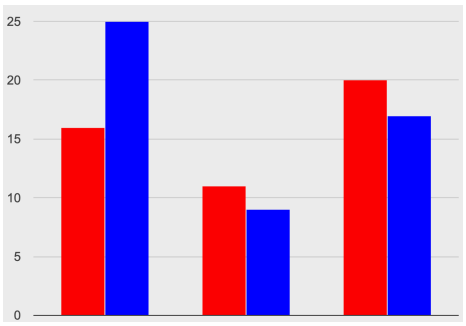
Matching Stacked and Multi Bar Charts

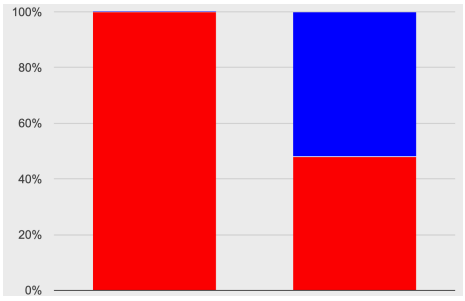
Match each stacked bar chart below to the multi bar chart that displays the same information.



1

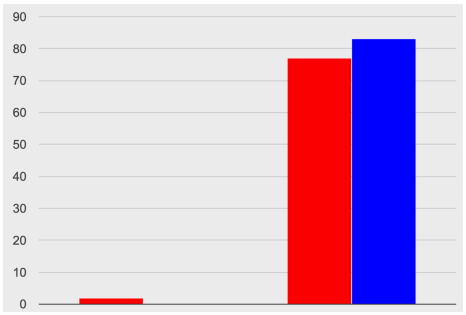
A

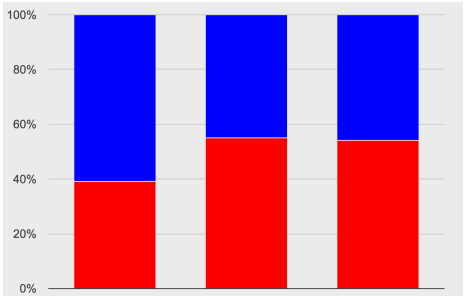




2

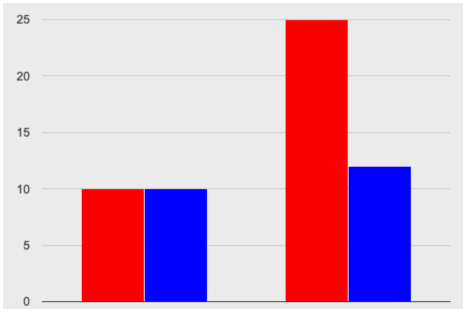
B

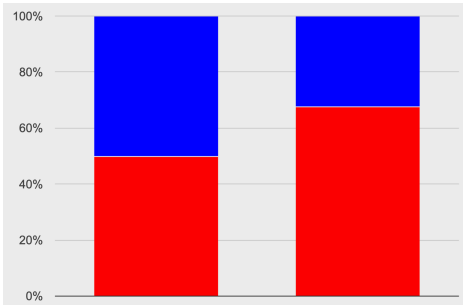




3

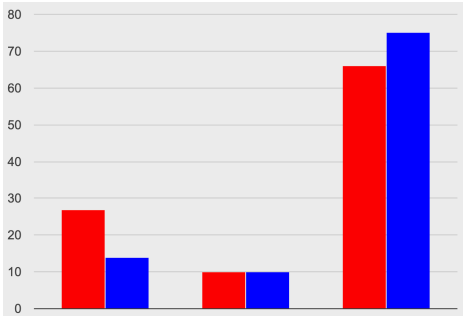
C





4

D



Making Infographics Rubric

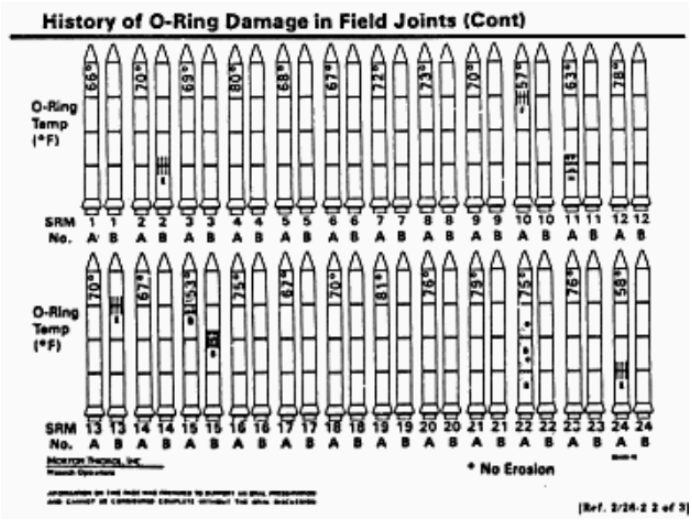
	Wow!	Getting There	Needs Improvement
Preparatory Work	The display or ratio statement formed a strong foundation for the rest of my infographic project.	The display or ratio statement needed revision in order to inspire a meaningful infographic (e.g., it was unclear or it was not interesting).	I did not create a display or ratio statement or what I produced was not conducive to creating a meaningful infographic.
Ratio statement: Impact	My ratio statement will really give those who read it something fascinating to contemplate!	My ratio statement is interesting but probably won't spark any deep conversations.	My ratio statement is dull and uninspired.
Images chosen: Accessibility	The imagery that I used when creating my infographic is inclusive. My images avoid stereotyping and help the viewer relate to and understand the topic.	The imagery that I used mostly avoids stereotyping. More inclusive imagery might help viewers connect with my topic better.	The imagery that I included reinforces stereotypes and might leave some viewers feeling disconnected from my message.
Infographic: Accuracy	The infographic is correctly drawn to scale (every element is in the same proportion).	There were some minor errors made in drawing the infographic to scale.	The infographic is not accurately scaled.
Infographic: Impact	The strategy that I chose (repeated images / bars on a grid / area model) makes sense for my ratio statement and has a strong impact.	The strategy that I chose makes sense but is not terribly impactful; another strategy might have been more effective at conveying my ratio statement.	The strategy that I chose did not make sense in this context nor did it have an impact.

Case Study: NASA Infographic

A day before the 1986 launch of the Challenger, a team of engineers urged NASA to postpone, arguing that launching in cold weather would be extremely dangerous. Parts called "O-rings", they said, were likely to crack in cold weather. A cracked O-ring could lead to a catastrophic explosion – and the death of every astronaut onboard.

Mission control asked the engineers to explain this risk with *data*.

To make their case, the engineers created an infographic that displayed outlines of 48 rockets, each representing a previous launch. Each rocket was labeled with the temperature at launch, with marks showing O-ring damage. These marks were explained in a legend, to help mission control understand what the damage was.



An infographic conveying O-ring damage in 48 rockets

Unfortunately, their infographic was very hard to read:

- Instead of sorting the rockets by *temperature* or *amount-of-damage* (the two variables the engineers claimed were related!), they were sorted by…the date they launched.
- The temperature at launch, which was the most important thing the engineers wanted mission control to see, was written *sideways*, in a tiny font that was difficult to read.
- The marks showing O-ring damage were hard to understand, and the legend that explained them *was on a separate page!*

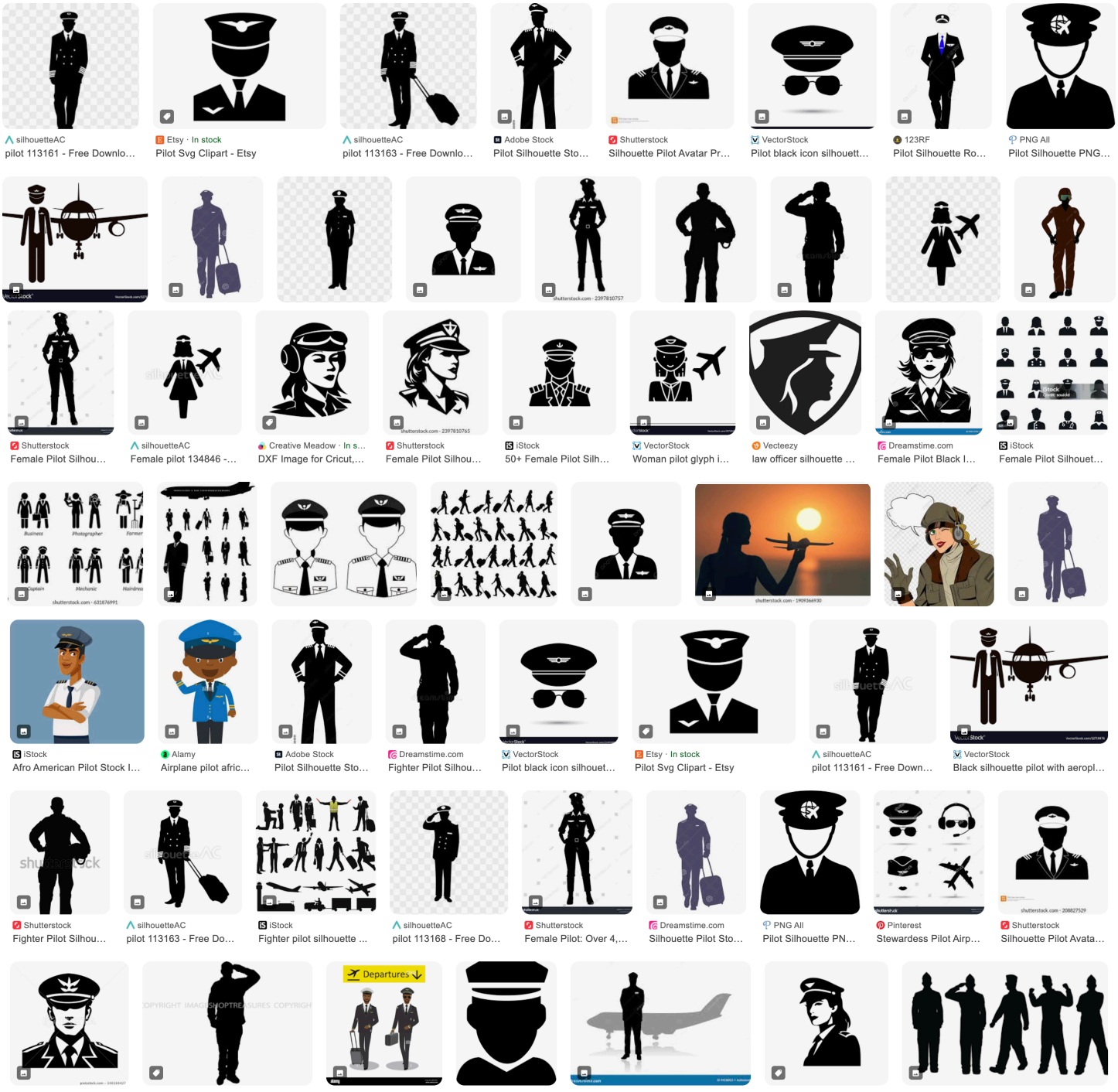
The engineers created an infographic that failed to clearly explain the risk, and mission control made the decision to go ahead with the launch.

73 seconds into the flight, the rocket exploded over the coast of Florida, killing everyone onboard. The tragedy crippled NASA, which did not launch another rocket for nearly three years.

…The Challenger's explosion was, in the end, attributed to O-ring failure.

Which Silhouette Might Work?

Below are screenshot of the top google search results for 1) pilot transparent silhouette 2) pilot silhouette female 3) pilot silhouette African American.



1) Put an x on images that read as male only.

2) Put a diagonal line on images that read as female only.

3) Put a horizontal line (--) through the images that read as a white pilot.

4) Circle one silhouette from the remaining images that you think could possibly work as a generalized image of a pilot.

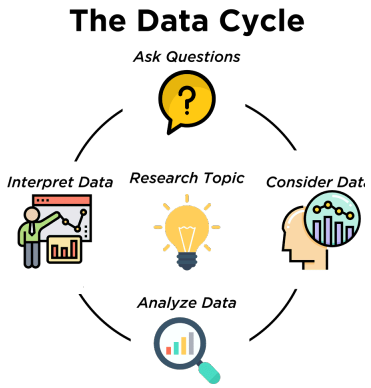
5) What do you Notice? What do you Wonder? _____

The Data Cycle

Data Science is all about *asking questions of data*.

- Sometimes the answer is easy to compute.
- Sometimes the answer to a question is *already in the dataset* - no computation needed.
- Sometimes the answer just sparks more questions!

Each question a Data Scientist asks adds a chapter to the story of their research. Even if a question is a "dead-end", it's valuable to share what the question was and what work you did to answer it!



- We start by **Asking Questions** after reviewing and closely observing the data. These questions can come from initial wonderings, or as a result of previous data cycle. Most questions can be broken down into one of four categories:
  - **Lookup questions** - Answered by only reading the table, no further calculations are necessary! Once you find the value, you're done! Examples of lookup questions might be "How many legs does Felix have?" or "What species is Sheba?"
  - **Arithmetic questions** - Answered by doing calculations (comparing, averaging, totaling, etc.) with values from one single column. Examples of arithmetic questions might be "How much does the heaviest animal weigh?" or "What is the average age of animals from the shelter?"
  - **Statistical questions** - These are questions that both *expect some variability in the data* related to the question and *account for it in the answers*. Statistical questions often involve multiple steps to answer, and the answers aren't black and white. When we compare two statistics we are actually comparing two data sets. If we ask "are dogs heavier than cats?", we know that not every dog is heavier than every cat! We just want to know if it is *generally* true or *generally* false!
  - **Questions we can't answer** - We might wonder where the animal shelter is located, or what time of year the data was gathered! But the data in the table won't help us answer that question, so as Data Scientists we might need to do some research beyond the data. And if nothing turns up, we simply recognize that there are limits to what we can analyze.

- Next, we **Consider Data**, by determining which parts of the data set we need to answer our question. Sometimes we don't have the data we need, so we conduct a survey, observe and record data, or find another existing dataset. Since our data is contained in a table, it's useful to start by asking two questions:
  - What rows do we care about? - Is it all the animals? Just the lizards?
  - What columns do we need? - Are we examining the ages of the animals? Their weights?

- Then, we **Analyze the Data**, by completing calculations, creating data displays, creating new tables, or filtering existing tables. The results of this step are calculations, patterns, and relationships.
  - Are we making a pie chart? A bar chart? Something else?

- Finally, we **Interpret the Data**, by answering our original question and summarizing the process we took and the results we found. Sometimes the data cycle ends here, but often these interpretations lead to new questions… and the cycle begins again.

Which Question Type?

name	type1	hitpoint	attack	defense	speed
Bulbasaur	Grass	45	49	49	45
Ivysaur	Grass	60	62	63	60
Venusaur	Grass	80	82	83	80
Mega Venusaur	Grass	80	100	123	80
Charmander	Fire	39	52	43	65
Charmeleon	Fire	58	64	58	80
Charizard	Fire	78	84	78	100
Mega Charizard X	Fire	78	130	111	100
Mega Charizard Y	Fire	78	104	78	100
Squirtle	Water	44	48	65	43
Wartortle	Water	59	63	80	58

Start by filling out **ONLY the "Question Type"** column of the table below.

Based on the Pokemon data above, decide whether each question is best described as:

- **Lookup** - Answered by only reading the table, no further calculations are necessary!
- **Arithmetic** - Answered by doing calculations (comparing, averaging, totalling, etc.) with values from one single column.
- **Statistical** - Best asked with "in general" attached, because the answer isn't black and white. If we ask "are dogs heavier than cats?", we know that not every dog is heavier than every cat! We just want to know if it is *generally true* or *generally false* !

	Question	Question Type	Which Rows?	Which Column(s)?
1	What type is Charizard?			
2	Which Pokemon is the fastest?			
3	What is Wartortle's attack score?			
4	What is the mean defense score?			
5	What is a typical defense score?			
6	Is Ivysaur faster than Venusaur?			
7	Is speed related to attack score?			
8	What is the most common type?			
9	Does one type tend to be faster than others?			
10	Are hitpoints (hp) similar for all Pokemon in the table?			
11	How many Fire-type Pokemon have a speed of 78?			

Data Cycle: Consider Data

Part 1: For each question below, identify the type of question and fill in the Rows and Columns needed to answer the question.

Ask Questions 	*How old is Boo-boo?* What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	

Ask Questions 	*Are there more cats than dogs in the shelter?* What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	

Part 2: Think of 2 questions of your own and follow the same process for them.

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	

Data Cycle: Distribution of Fixed Animals

Using the Expanded Animals Starter File, let's make a **bar chart** to see what we can learn about the distribution of fixed animals and what new questions it may lead us to.

Ask Questions

Are more animals fixed or unfixed?
What question do you have?

Question Type (circle one):
Lookup
Arithmetic
Statistical

Consider Data

All the rows
Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.)

fixed
What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)

Analyze Data

What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?

Interpret Data

The chart shows that there are _____ fixed animals _____ unfixed animals.
(more / less / about the same number of) (as / than)

Some new questions this raises include:

Let's make a **stacked-bar-chart** to see if the ratio of fixed to unfixed animals differs by species.

Ask Questions

How does the ratio of fixed to unfixed animals differ by species?
What question do you have?

Question Type (circle one):
Lookup
Arithmetic
Statistical

Consider Data

Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.)

What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)

Analyze Data

What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?

Interpret Data

The stacked bar chart shows that _____ species have _____ fixed animals _____ unfixed animals.
(all / most / some / a few / no) (more / the same number of / fewer) (as / than)

I also notice _____

Some new questions this raises include:

Data Cycle: Distribution of Categorical Columns

Open the Expanded Animals Starter File. Explore the distribution of a categorical column using **pie-chart** or **bar-chart**.

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	❏ The chart shows that there is an even distribution of _____ (variable). ❏ The chart shows that the most common _____ (variable) is/are _____ I notice that _____ I wonder _____ • How does the distribution of _____ (variable) differ by _____ (variable)? • _____ Another question I have is…	

Explore the distribution of two categorical columns using **stacked-bar-chart** or **multi-bar-chart**.

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	When we break the distribution of _____ (variable) down by _____ (variable): • I notice that _____ • I wonder _____ Another question I have is…	

Question Types: Animals

A subset of the whole Animals Dataset is shown in the table below.

name	species	sex	age	fixed	legs	pounds	weeks
Sasha	cat	female	1	false	4	6.5	3
Sunflower	cat	female	5	true	4	8.1	6
Felix	cat	male	16	true	4	9.2	5
Sheba	cat	female	7	true	4	8.4	6
Billie	snail	hermaphrodite	0.5	false	0	0.1	3
Snowcone	cat	female	2	true	4	6.5	5
Wade	cat	male	1	false	4	3.2	1
Hercules	cat	male	3	false	4	13.4	2
Toggle	dog	female	3	true	4	48	1

Using this table - or the full dataset - write three questions of each type below.

- **Lookup** - Answered by only reading the table, no further calculations are necessary!
- **Arithmetic** - Answered by doing calculations (comparing, averaging, totalling, etc.) with values from one single column.
- **Statistical** - Best asked with "in general" attached, because the answer isn't black and white. If we ask "are dogs heavier than cats?", we know that not every dog is heavier than every cat! We just want to know if it is *generally true* or *generally false* !

	Type	Question
1	Lookup	
2	Lookup	
3	Lookup	
4	Arithmetic	
5	Arithmetic	
6	Arithmetic	
7	Statistical	
8	Statistical	
9	Statistical	

Data Cycle: Analyzing with Count

For each question below, complete the first three steps of the Data Cycle.
Once you know what display, measure, or table you'd like to make, create it in CODAP.

Ask Questions 	*How many of each species are at the shelter?* What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	

Ask Questions 	*How many of each sex are at the shelter?* What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	

For the final Data Cycle, develop your own question and complete the remaining steps.

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	

Snack Habits Rubric

	Wow!	Getting There	Needs Improvement
Data collection	I filled in the Google form each and every time I had a snack. If I was unable to complete the form at the time of the snack, I made a point of completing it as soon as possible. When I responded to the prompts, I gave accurate information (acquired by looking at the nutritional label). This snacking log perfectly accurately represents my snacking.	I filled in the Google form almost every time I had a snack. When I responded to the prompts, I tried my best to give accurate information, but sometimes I made guesses about the number of servings, calories per serving, etc. Overall, the accuracy of the data collected is decent, however.	I often forgot to fill in the Google form when I snacked. I had to go back and dig through my memories to make educated guesses about my snacking habits. The information recorded during the data collection phase is most likely not an accurate depiction of my snacking habits.
Part 1: Our Snacking Habits	I've reflected on the process of tracking my snacking habits, providing interesting details about what I learned. I have offered meaningful noticings and wonderings about our class' snacking habits. I shared a display that I found interesting.	My reflections on the process of tracking my snacking habits are brief and would benefit from additional detail. The observations I shared about our class' snacking habits were shallow. I shared a display, but it was not necessarily interesting.	My reflections on snack tracking and our class dataset are brief, confusing, or missing entirely.
Part 2: US Snacking Habits	I've included an interesting graph and/or statistic from a credible source to represent America's snacking habits. At the end of the slide deck, I've credited my sources. I have explained why the graph caught my attention and what it made me wonder.	I've included a graph and/or statistic to represent America's snacking habits, but the source is not entirely credible. My explanation of why I have chosen this graph is not compelling.	I have either forgotten to include a graph/statistic to represent America's snacking habits, or the graph/statistic that I chose is not appropriate for this project.
Part 3: My statistical question and its answer	I developed a compelling and interesting statistical question based on the data I collected. I clearly answered that question by presenting plots, tables, photos and thoughtful written analysis.	The statistical question I chose is not fully answered by the data presented. I have put in some effort to answer the question with plots, tables, photos and written analysis, but more detail is needed.	Either my statistical question is simple and straightforward, and answering it did not require much critical analysis by me, or my statistical question was not adequately answered by my graphics and written analysis.
Part 4: Conclusion & Sources	I truthfully and honestly answered all questions about the challenges of this project. I addressed in detail how the project's challenges might have affected the quality of my data. I've provided accurate source information.	My discussion of the challenges of this project was brief and lacking in detail. I only partially addressed how this project's challenges might have affected the quality of my data. I've provided some source information.	I did not offer enough thoughtful discussion on the challenges of collecting data. It is not clear to the reader that I understand how challenges I encountered could affect the quality of the data. My source information is missing or inaccurate.

Snack Habits Data

For our purposes, a snack is any food or beverage other than water that you consume between meals.

1) Below is a table of the prompts you will see in the google form you will be completing for each snack you consume over the next 5 days. What do you Notice? What do you Wonder?

2) Complete the table by defining each variable's data type (Number,String, Boolean, Image…).

Prompt	Variable Name	Data Type
Time you ate the Snack *Format: The nearest hour on the 24-hour clock (e.g. 4am = 4, 4pm = 16)*	time	
Date you ate the Snack *Format: 09/23/24*	date	
True or False: You ate this snack on a day you went to school?	is-school-day	
What's the name of the snack?	name	
Is your snack salty? sweet? Or neither?	salty-sweet	
How many servings did you eat?	servings	
How many calories per serving?	calories	
How many grams of total fat per serving?	fat	
How many milligrams of sodium per serving?	sodium	
How many grams of sugar per serving?	sugar	
How healthy do you think the snack is? *(1- very unhealthy; 5- very healthy)*	health-level	
In one word, describe why you are eating the snack.	why	
How much does this snack cost?	cost	
How many ingredients are in this snack?	ingredients	
Take a photo of your snack or beverage. *(Your teacher may or may not have included this in the actual google form, but having some images of your snacks will probably be useful for your final project.)*	snack-image	

Note: Most snacks come in packages with nutritional value labels that will help you to answer many of these questions. When eating a snack whose package does not include the nutritional value, a simple google search will return an image that looks just like those labels, e.g. "Nutritional Value of an Apple". Similarly, if you get a snack from the cupboard rather than the store, you can google for the price.

Snack Habits Check-In

Name: _____

1) How well have you done collecting data for this project? Circle one of the choices below and explain why you ranked it at that level.
(5) Excellent (4) Very Well (3) Average (2) Below Average (1) Not as well as I wanted (0) Collected no data

2) If you are struggling with data collection, what changes are you going to make so that you can do a better job moving forward?

3) Have you faced any obstacles when it comes to data entry? What were they and how did you overcome them?

4) Do you have any tips for someone who is struggling to stay on top of data entry?

5) Has the process of collecting your own snack data influenced or altered your snacking habits at all? Explain.

6) Do you think it will affect the quality of data? What types of snacks might people not be entering?

Data Cycle: Distribution of Categorical Columns

Explore the distribution of categorical columns in your class' snacking data using **pie-chart**, **bar-chart**, **stacked-bar-chart** or **multi-bar-chart**.

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	❏ The chart shows that there is an even distribution of _____ (variable). ❏ The chart shows that the most common _____ (variable) is/are _____ I notice that _____ I wonder _____ • How does the distribution of _____ (variable) differ by _____ (variable)? • _____ Another question I have is...	

Explore the distribution of categorical columns in your class' snacking data using **pie-chart**, **bar-chart**, **stacked-bar-chart** or **multi-bar-chart**.

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	When we break the distribution of _____ (variable) down by _____ (variable): • I notice that _____ • I wonder _____ Another question I have is...	

U.S. Snack Habits

1) Choose one statistic (or the title of a display) you found about US snacking habits: _____

2) What is the source? _____

3) What information is available re: the data collection process? (For example: year of data collection, sample size, how the sample was selected, reason for data collection, etc.) You may need to do some digging. _____

4) Based on the above information, what makes you think this data is credible? _____

5) What are some **similarities** between our class snacking habits and the US snacking habits data you found?

6) What are some **differences** between our class snacking habits and the US snacking habits data you found?

7) Do you have any guesses about why the data are similar / different in the ways that you have identified? _____

8) Does anything you turned up in your research surprise you? _____

Probability, Inference, and Sample Size

How can you tell if a coin is fair, or designed to cheat you? Statisticians know that a fair coin should turn up "heads" about as often as "tails", so they begin with the **null hypothesis:** they assume the coin is fair, and start flipping it over and over to record the results.

A coin that comes up "heads" three times in a row could still be fair! The odds are 1-in-8, so it's totally possible that the null hypothesis is still true. But what if it comes up "heads" five times in a row? Ten times in a row?

Eventually, the chances of the coin being fair get smaller and smaller, and a Data Scientist can say "this coin is a cheat! The chances of it being fair are one in a million!"

By sampling the flips of a coin, we can *infer* whether the coin itself is fair or not.

Using information from a sample to draw conclusions about the larger population from which the sample was taken is called **Inference** and it plays a major role in Data Science and Statistics! For example:

- If we survey pet owners about whether they prefer cats or dogs, the **null hypothesis** is that the odds of someone preferring dogs are about the same as them preferring cats. And if the first three people we ask vote for dogs (a 1-in-8 chance), the null hypothesis could still be true! But after five people? Ten?
- If we're looking for gender bias in hiring, we might start with the null hypothesis that no such bias exists. If the first three people hired are all men, that doesn't necessarily mean there's a bias! But if 30 out of 35 hires are male, this is evidence that undermines the null hypothesis and suggests a real problem.
- If we poll voters for the next election, the **null hypothesis** is that the odds of voting for one candidate are the same as voting for the other. But if 80 out of 100 people say they'll vote for the same candidate, we might reject the null hypothesis and infer that the population as a whole is biased towards that candidate!

Sample size matters! The more bias there is, the smaller the sample we need to detect it. Major biases might need only a small sample, but subtle ones might need a huge sample to be found. However, choosing a **good sample** can be tricky!

Random Samples are a subset of a population in which each member of the subset has an equal chance of being chosen. A random sample is intended to be a representative subset of the population. The larger the random sample, the more closely it will represent the population and the better our inferences about the population will tend to be.

Grouped Samples are a subset of a population in which each member of the subset was chosen for a specific reason. For example, we might want to look at the difference in trends between two groups ("Is the age of a dog a bigger factor in adoption time v. the age of a cat?"). This would require making grouped samples of *just the dogs* and *just the cats.*

Finding the Trick Coin

Open the Fair Coins Starter File, which defines `coin1`, `coin2`, *and* `coin3`. *Click "Run".*
You can flip each coin by evaluating `flip(coin1)` *in the Interactions Area (repeat for coins 2 and 3).*
*One of these coins is fair, one will land on "heads" 75% of the time, and one will land on "heads" 90% of the time. *Which one is which?**

1) Complete the table below by recording the results for five flips of each coin and *totalling* the number of "heads" you saw.
Convert the ratio of heads to flips into a *percentage*. Finally, decide whether or not you think each coin is *fair* based on your sample.

Sample	coin1		coin2		coin3	
1	H	T	H	T	H	T
2	H	T	H	T	H	T
3	H	T	H	T	H	T
4	H	T	H	T	H	T
5	H	T	H	T	H	T
#heads	/5		/5		/5	
% heads	%		%		%	
fair?	Y	N	Y	N	Y	N

2) Record 15 more flips of each coin in the table below and *total* the number of "heads" you saw *in all 20 flips of each coin*.
Convert the ratio of total heads to total flips into a *percentage*. Finally, decide whether you think each coin is fair based on this larger sample.

Sample	coin1		coin2		coin3	
6	H	T	H	T	H	T
7	H	T	H	T	H	T
8	H	T	H	T	H	T
9	H	T	H	T	H	T
10	H	T	H	T	H	T
11	H	T	H	T	H	T
12	H	T	H	T	H	T
13	H	T	H	T	H	T
14	H	T	H	T	H	T
15	H	T	H	T	H	T
16	H	T	H	T	H	T
17	H	T	H	T	H	T
18	H	T	H	T	H	T
19	H	T	H	T	H	T
20	H	T	H	T	H	T
#heads	/20		/20		/20	
% heads	%		%		%	
fair?	Y	N	Y	N	Y	N

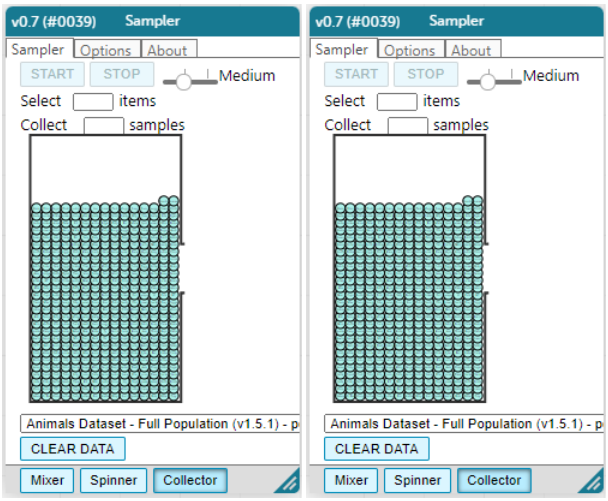
3) Which coin was the easiest to identify? fair? 75%? 90%?

4) Why was that coin the easiest to identify? _____

_____

Sampling and Inference

1) In the screenshots of the "Sampler" (below), show how you would create a small random sample of 10 animals and a large random sample of 40 animals. *To create two separate tables (rather than a single hierarchical table), re-select and re-open "Sampler" from the Plugins menu before each sampling simulation.*



2) In the options tab, did you select "with replacement" or "without replacement"? Why?

3) Make a bar chart for the animals in each sample, showing percentages of fixed and unfixed.

- The percentage of fixed animals in the entire population is: **47.7%**
- The percentage of fixed animals in the small sample is: _____
- The percentage of fixed animals in the large sample is: _____

4) Make a bar chart for the animals in each sample, showing percentages for each species.

- The percentage of tarantulas in the entire population is: **roughly 5%**
- The percentage of tarantulas in the small sample is: _____
- The percentage of tarantulas in the large sample is: _____

5) Direct the sampler to generate a different set of random samples of these sizes. Make a new bar chart for each sample, showing percentages for each species.

- The percentage of tarantulas in the entire population is: **roughly 5%**
- The percentage of tarantulas in the small sample is: _____
- The percentage of tarantulas in the large sample is: _____

6) Which repeated sample gave us a more accurate inference about the whole population? Why?

Predictions from Samples

1) Use the Sampler plugin to create the following tables and give them the specified names. (Re-open Sampler *before* creating each table to avoid getting one massive hierarchical table!)

- 10 animals randomly selected without replacement ⇒ `tiny-sample`
- 20 animals randomly selected without replacement ⇒ `small-sample`
- 40 animals randomly selected without replacement ⇒ `medium-sample`
- 80 animals randomly selected without replacement ⇒ `large-sample`

2) Make a bar chart of the species in the `tiny-sample`.

- What animals are in the sample? _____
- Create a new, random, `tiny-sample`, and use it to make a bar-chart. What animals are in the sample? _____
- Make *another* tiny sample and bar chart of species. Based on these samples, how many species do you think are at the shelter? _____
- Which species do you think there are the most of at the shelter? _____

3) What did you learn from taking multiple samples that you wouldn't have known if you'd only taken a single sample?

_____

4) Now use `small-sample` to make a bar chart of the species.

- What animals are in the sample? _____
- Create a new random sample and make another bar chart of species in the small sample. What animals are in the sample? _____

5) Now that you've seen the small sample, how has your sense of the distribution of the species changed?

_____

6) Now use the medium sample to make a bar chart of the species. If there are about 400 animals at the shelter, how many of each species would you predict there to be?

_____

7) Now use the large to make a bar chart of the species. If there's anything you'd like to change about your prediction now that you've seen the large sample, record it here.

_____

8) Let's see how accurate your prediction is… When you're ready, make a bar chart of Animals Table 2.

- Which predictions were closest? _____
- Which predictions were off? _____
- Were there any surprises? _____

9) In the real world, we usually don't have access to a whole dataset to check predictions against! How could we test…

- *Every giraffe on the planet?*
- *Everyone who has ever come in contact with a covid-positive person?*
- *Every person who identifies as queer?*

What strategies can we use to make sure that predictions from samples are as close to accurate as possible?

_____

_____

Choosing Your Dataset

When selecting a dataset to explore, *pick something that matters to you!* You'll be working with this data for a while, so you don't want to pick something at random just to get it done.

When choosing a dataset, it's a good idea to consider a few factors:

1. Is it **interesting**?
   Pick a dataset you're genuinely interested in, so that you can explore questions that fascinate you!

2. Is it **relevant**?
   Pick a dataset that deals with something personally relevant to you and your community!
   Does this data impact you in any way?
   Are there questions you have about the dataset that mean something to you or someone you know?

3. Is it **familiar**?
   Pick a dataset you know about, so you can use your expertise to deepen your analysis! You wouldn't be able to make samples of the Animals Dataset properly if you didn't know that some animals are much bigger or longer-lived than others.

Consider and Analyze

Fill in the tables below by considering the rows and columns you need. If time allows, type your code into CODAP to see your display!

1) A dot plot showing the `species` of animals from the shelter.

Which Rows?	Which Column(s)?	What will you Create?
All the animals		

2) A `bar-chart` showing the `sex` of animals from the shelter.

Which Rows?	Which Column(s)?	What will you Create?
All the animals		

3) A `histogram` of the number of `pounds` that animals weigh.

Which Rows?	Which Column(s)?	What will you Create?
All the animals		

4) A `box-plot` of the number of `pounds` that animals weigh.

Which Rows?	Which Column(s)?	What will you Create?
All the animals		

5) A `scatter-plot`, using the animals' `species` as the labels, `age` as the x-axis, and `pounds` as the y-axis.

Which Rows?	Which Column(s)?	What will you Create?
All the animals		

6) A `scatter-plot`, using the animals' `name` as the labels, `pounds` as the x-axis, and `weeks` as the y-axis.

Which Rows?	Which Column(s)?	What will you Create?
All the animals		

My Dataset

The _____ dataset contains _____ data rows.

1) I'm interested in this data because _____

_____

2) My friends, family or neighbors would be interested because _____

_____

3) Someone else should care about this data because _____

_____

4) In the table below, write down what you Notice and Wonder about this dataset.

What do you NOTICE?	What do you WONDER?	Question
		Lookup Arithmetic Statistical Can't Answer
		Lookup Arithmetic Statistical Can't Answer
		Lookup Arithmetic Statistical Can't Answer
		Lookup Arithmetic Statistical Can't Answer
		Lookup Arithmetic Statistical Can't Answer
		Lookup Arithmetic Statistical Can't Answer

5) Consider each Wonder you wrote above and Circle what type of question it is.

Choose two columns to describe below.

6) _____ (column name), which contains _____ (categorical/quantitative) data. Example values from this column include:

_____

7) _____ (column name), which contains _____ (categorical/quantitative) data. Example values from this column include:

_____

Data Cycle: Categorical Data

Use the Data Cycle to explore the distribution of one or more categorical columns using **pie-charts and bar-charts** , and record your findings.

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	What did you find out? What can you infer? What - if any - new question(s) does this raise?	

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	What did you find out? What can you infer? What - if any - new question(s) does this raise?	

Datasets and Starter Files

Click through the datasets below. *(Your teacher might also ask you to work with Global Food Supply [Starter File].)* When you find one you'd like to use in Pyret, (1) click the "Starter File" link to open it in a new tab and (2) select "Save a copy" from the "File" menu.

★ *Looking for a shorter list? We've starred a few good beginner datasets.*

The Environment & Health

Global Waste by Country 2019	Dataset
World Cities' Proximity to the Ocean	Dataset
Earthquakes	Dataset
Air Quality, Pollution Sources & Health in the U.S.	Dataset
Health by U.S. County	Dataset
COVID in the U.S. by County	Dataset
Arctic Sea Ice	Dataset

Politics

Countries of the World	Dataset
Gerrymandering	Dataset
Marijuana Laws & Arrests by State 2018	Dataset
LAPD Arrests 2010-2019	Dataset
NYPD Stop, Search & Frisk 2019	Dataset
Refugees 2018	Dataset
State Demographics	Dataset
U.S. Income	Dataset
U.S. Jobs	Dataset
U.S. Voter Turnout 2016	Dataset

Sports

Esports Earnings	Dataset
MLB Hitting Stats	Dataset
NBA Players	Dataset
NFL Passing	Dataset
NFL Rushing	Dataset

Entertainment

★Movies	Dataset
IGN video game Reviews	Dataset
International Exhibition of Modern Art	Dataset
North American Pipe Organs	Dataset
Pokemon	Dataset
Music	Dataset

Education

College Majors	Dataset

U.S. Colleges 2019-2020	Dataset
★R.I. Schools	Dataset
Evolution of College Admissions in California	Dataset

Nutrition

Soda, Coffee & Other Drinks	Dataset
Fast Food Nutrition	Dataset

Would you like to contribute a dataset of your own, or is there something you'd like to change about one of ours?

Rubric: Exploration Project (1)

About this Dataset

Wow! ☐	Getting There ☐	Needs Improvement ☐
I explained why this dataset is interesting to me, others like me, and why others should care about it. I considered why the dataset was collected, and what purpose it might serve. I correctly identified all rows, columns, and types in my dataset.	I explained why this dataset was interesting to me and at least one other person/group, and shared *something* about where it came from. I correctly identified most of the rows, columns, and types in my dataset.	I explained why this dataset was interesting to me, and shared *something* about where it came from. I correctly identified some rows, columns, and types in my dataset.

Criteria for Displays

Wow!	Getting There	Needs Improvement
I either included multiple displays of this type or wrote about why I my data didn't allow for multiple. I indicated which column(s) I used and described how I made it. I made a strong attempt to interpret the interesting displays and report about the displays that weren't useful. I added the questions that emerged to the "My Questions" section.	I included one display of this type. I provided the column name and a description of how I made it. My interpretation lacked detail. I added the questions that emerged to the "My Questions" section.	I included one or no displays of this type. My slides may be missing a correct column name or description of how I made the display. My data interpretation may be missing or inaccurate. I may not have added to the "My Questions" section.

Displays	Rating	Teacher Feedback
Bar Chart	❏ Wow ❏ Getting There ❏ Needs Improvement	
Pie Chart	❏ Wow ❏ Getting There ❏ Needs Improvement	
Histogram	❏ Wow ❏ Getting There ❏ Needs Improvement	
Box Plot	❏ Wow ❏ Getting There ❏ Needs Improvement	

Rubric: Exploration Project (2)

Measures of Center

Wow! ☐	Getting There ☐	Needs Improvement ☐
I selected at least two columns in my dataset, and correctly filled out the entire summary table for each one (or wrote about why my data didn't allow for this). Based on these measures, I decided which measure of center was best for each column, and I provided a detailed interpretation of what these measures tell me about the dataset.	I selected at least two columns in my dataset (or wrote about why my data didn't allow for this), and correctly filled out the entire summary table for each one. I tried to interpret what these measures tell me about the dataset, but my interpretation lacked detail.	I filled out most of the table but didn't demonstrate understanding of what these measures tell about the dataset.

Correlation and Linear Regression

Wow! ☐	Getting There ☐	Needs Improvement ☐
I either included multiple scatterplots or wrote about why my data didn't allow for multiple. I described my observations, including identifying outliers and patterns that could point to possible correlations. If the scatter plot didn't reveal any patterns or outliers, I wrote about that. When the corresponding linear regression plot(s) showed a correlation, I included an additional slide and a thoughtful interpretation.	I included at least one scatter plot with cursory descriptions and observations. I included a slide of a linear regression plot showing a correlation or described why I didn't include any linear regression plots.	I added at least one slide about a scatter plot. The description and/or display may be lacking. I may have left out the linear regression, included one that didn't reveal a correlation, or offered an incorrect interpretation of it.

My Questions

Wow! ☐	Getting There ☐	Needs Improvement ☐
I had lots of questions by the end of the exploration, and I chose at least two that I thought were most interesting. I explained why I thought they were interesting, and wrote about grouped samples that might be good to explore when answering those questions.	I had a few questions by the end of the exploration, and I chose at least one that was interesting. I wrote about grouped samples that might be good to explore.	I picked a question, and wrote about grouped samples.

Additional Teacher Feedback

Histograms

To best understand histograms, it's helpful to contrast them first with bar charts.

Bar charts show the number of rows belonging to a given category. The more rows in each category, the taller the bar.

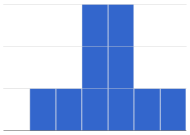
- Bar charts provide a visual representation of the frequency of values in a **categorical** column.
- There's no strict numerical way to order these bars.
  - The count of red, yellow and blue balloons would make sense no matter what order they get presented in.
  - But **sometimes there's an order that makes sense**. For example, it would be logical to show the count of t-shirt sizes in order of smallest to largest shirt.

Histograms show the number of rows that fall within certain intervals, or "bins", on a horizontal axis. The more rows that fall within a particular "bin", the taller the bar.

- *Histograms provide a visual representation of the frequencies (or relative frequencies) of values in a* ***quantitative*** *column.*
- Quantitative data **can always be ordered**, so the bars of a histogram always progress from smallest (on the left) to largest (on the right).
- When dealing with histograms, it's important to select a good **bin size**. If the bins are too small or too large, it is difficult to see the shape of the dataset. Choosing a good bin size can take some trial and error!

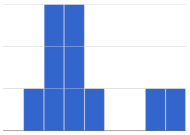
The **shape** of a dataset tells us which values are more or less common.

- In a **symmetric** dataset, values are just as likely to occur a certain distance above the mean as below the mean. Each side of a symmetric distribution looks almost like a mirror-image of the other.



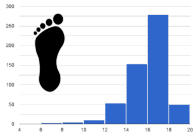
- Some extreme values may be far greater or far lower than the other values in a dataset. These extreme values are called **outliers**.
- A dataset that is **skewed left** has a few values that are unusually low. The histogram for a skewed left dataset has a few data points that are stretched out to the left (lower) end of the x-axis.

- A dataset that is **skewed right** has a few values that are unusually high. The histogram for a skewed right dataset has a few data points that are stretched out to the right (higher) end of the x-axis.

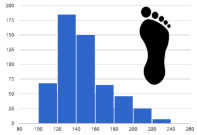


- One way to visualize the difference between a histogram of data that is **skewed left** or **skewed right** is to think about the lengths of our toes on our left and right feet.

Much like the bar lengths of a histogram that is "skewed left", our left feet have smaller toes on the left and a bigger toe on the right.



Our right feet have the big toe on the left and smaller toes on the right, more closely resembling the shape of a histogram of "skewed right" data.

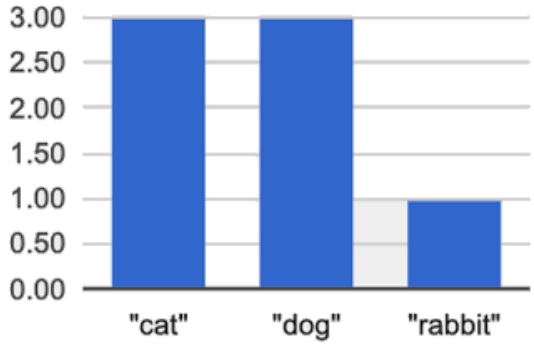


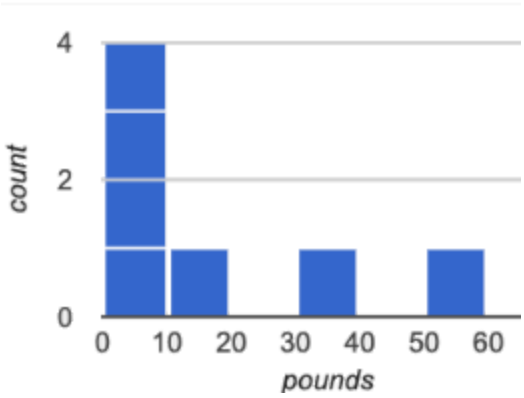
Summarizing Columns with Bar Charts & Histograms

name	species	age	pounds
"Sasha"	"cat"	1	6.5
"Boo-boo"	"dog"	11	12.3
"Felix"	"cat"	16	9.2
"Nori"	"dog"	6	35.3
"Wade"	"cat"	1	3.2
"Nibblet"	"rabbit"	6	4.3
"Maple"	"dog"	3	51.6

1	How many cats are there in the table above?	
2	How many dogs are there?	
3	How many animals weigh between 0 and 20 pounds?	
4	How many animals weigh between 20 and 40 pounds?	
5	Are there more animals weighing 40-60 pounds than 60-140 pounds?	

The two displays below both summarize this table. The display on the left is a **Bar Chart**, while the one on the right is a **Histogram**. What is similar about them? What is different?





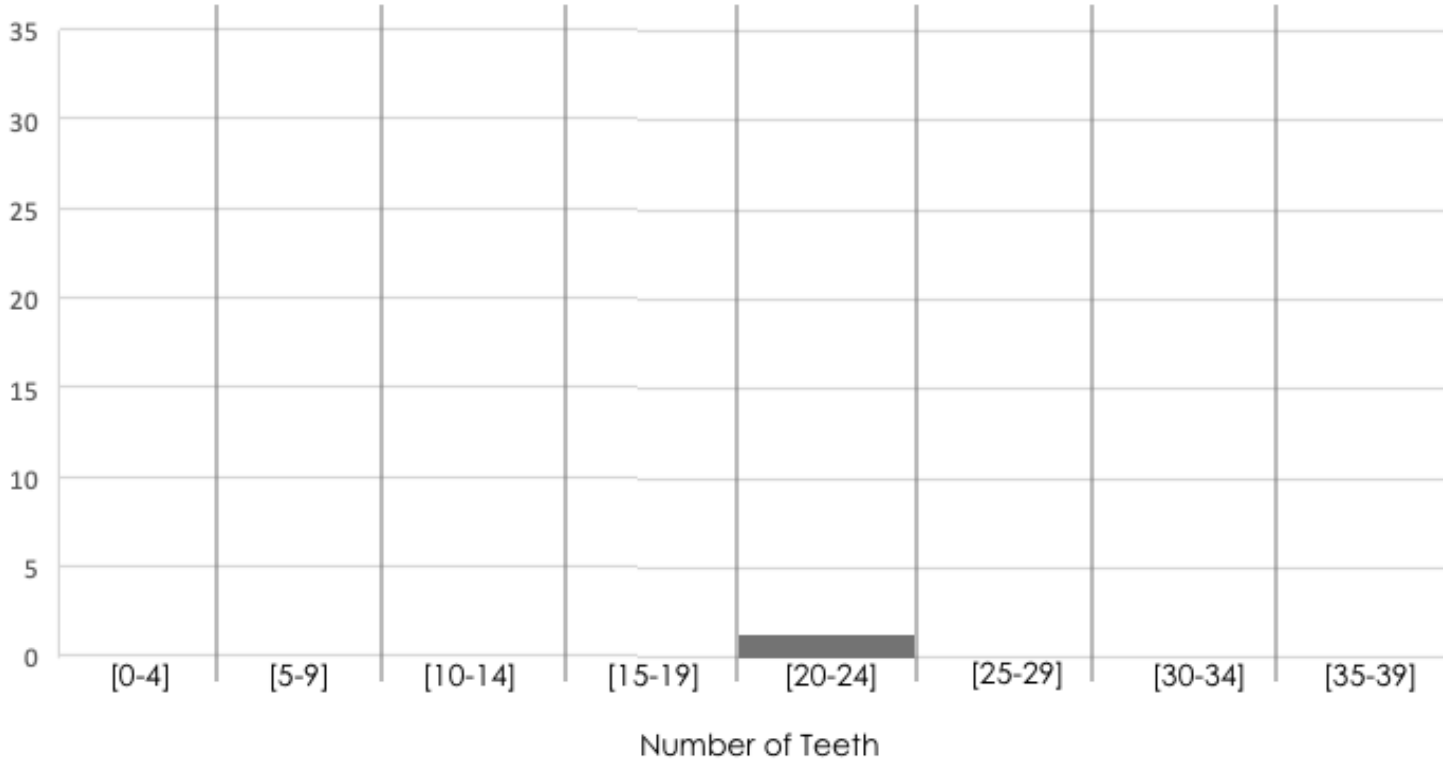
Similarities	Differences

Making Histograms

Suppose we have a dataset for a group of 50 adults, showing the number of teeth each person has:

Number of teeth	Count
0	5
22	1
26	1
27	1
28	4
29	3
30	5
31	3
32	27

Draw a histogram for the table in the space below. For each row, find which interval (or "bin") on the x-axis represents the right number of teeth. Then fill in the box so that its height is equal to the *sum of the counts* that fit into that interval. One of the intervals has been completed for you.

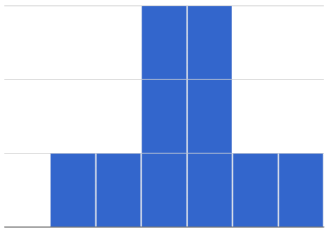
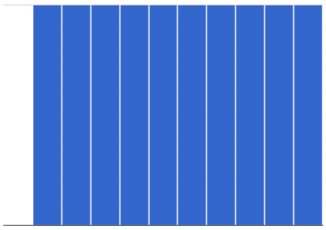
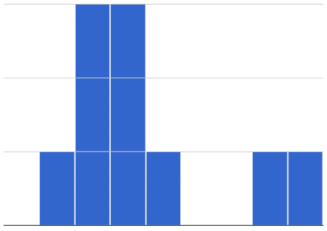
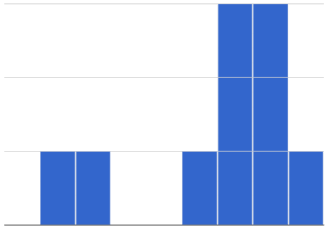
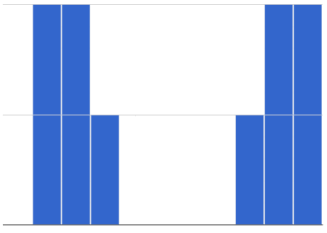


Reading Histograms

Students watched 5 videos, and rated them on a scale of 1 to 10. The average score for every video is the same (5.5).

Match the summary description (left) with the *shape* of the histogram of student ratings (right).

- The x-axis shows the score, and the y-axis shows the number of students who gave it that score.
- These axes are intentionally unlabeled - the **shapes** of the ratings distributions were very different! And that's the focus here.

Most of the students were fine with the video, but a couple of them gave it an unusually low rating.	**1**	**A**	
Most of the students were okay with the video, but a couple students gave it an unusually high rating.	**2**	**B**	
Students tended to give the video an average rating, and they weren't likely to stray far from the average.	**3**	**C**	
Students either really liked or really disliked the video.	**4**	**D**	
Reactions to the video were all over the place: high ratings and low ratings and inbetween ratings were all equally likely.	**5**	**E**	

Choosing the Right Bin Size

Open your saved Animals Starter File, or make a new copy. After dragging an attribute to an axes, select Group into Bins from the Configuration menu. Fuse dots into bars, then enter the desired bin width.

Make a histogram for the "weeks" column in the animals-table, using a bin size of 10 and the "name" column for your labels.

1) How many animals took between 0 and 10 weeks to be adopted? _____

2) How many animals took between 10 and 20 weeks to be adopted? _____

Try some other bin sizes (be sure to experiment with bigger and smaller bins!)

3) What shape emerges? _____

4) What bin size gives you the best picture of the distribution? (Note: *ideally your histogram should have between 5 and 10 bars*) _____

5) Are there any outliers? If so, are they high or low? _____

6) How many animals took between 0 and 5 weeks to be adopted? _____

7) How many animals took between 5 and 10 weeks to be adopted? _____

8) What else do you Notice? What do you Wonder?

_____

_____

_____

_____

_____

_____

_____

_____

9) What was a typical time to adoption?

_____

_____

Data Cycle: Shape of the Animals Dataset

Use the Data Cycle to explore the distribution of one or more quantitative columns in Animals Starter File using **histograms**.

Ask Questions

What is the shape of the age column of the Animals dataset?
What question do you have?

Question Type (circle one):
Lookup
Arithmetic
Statistical

Consider Data

Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.)

What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)

Analyze Data

What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?

Interpret Data

The histogram I created is for _____ (x-variable in context) from _____ (dataset or subset).

The bin size I chose is _____ (bin size), which resulted in a histogram with _____ (how many?) bins. I chose this bin size because

I would describe the shape of this histogram as _____

I notice that _____
Consider statements like: Most of the histogram's area is… / A small amount of the histograms area trails out… / etc

I wonder _____

Ask Questions

What question do you have?

Question Type (circle one):
Lookup
Arithmetic
Statistical

Consider Data

Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.)

What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)

Analyze Data

What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?

Interpret Data

The histogram I created is for _____ (x-variable in context) from _____ (dataset or subset).

The bin size I chose is _____ (bin size), which resulted in a histogram with _____ (how many?) bins. I chose this bin size because

I would describe the shape of this histogram as _____

I notice that _____
Consider statements like: Most of the histogram's area is… / A small amount of the histograms area trails out… / etc

I wonder _____

Data Cycle: Shape of My Dataset

Use the Data Cycle to explore the distribution of one or more quantitative columns from your chosen dataset using **histograms**, and write down your findings.

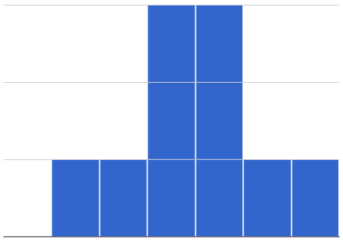
Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	If you only need some rows, write an expression for your Filter Transformer here. If you need to Transform or Build an attribute, write the expression for your Transformer here. What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	What did you find out? What can you infer? What - if any - new question(s) does this raise?	

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	If you only need some rows, write an expression for your Filter Transformer here. If you need to Transform or Build an attribute, write the expression for your Transformer here. What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	What did you find out? What can you infer? What - if any - new question(s) does this raise?	

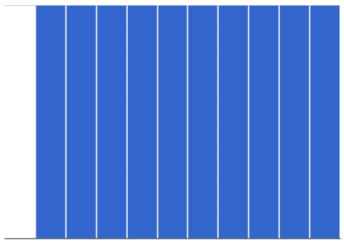
Identifying Shape - Histograms

Describe the shape of the histograms on the left. Do your best to incorporate the vocabulary you've been introduced to.

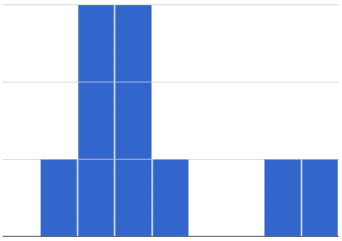
1



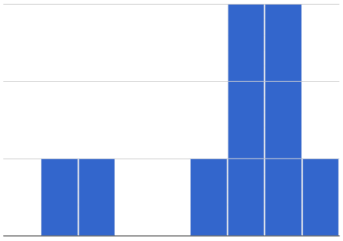
2



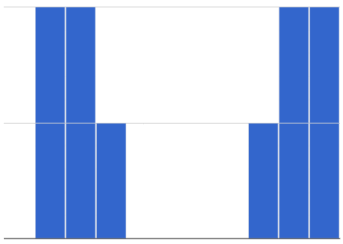
3



4



5



Data Cycle: Shape of the Animals Dataset

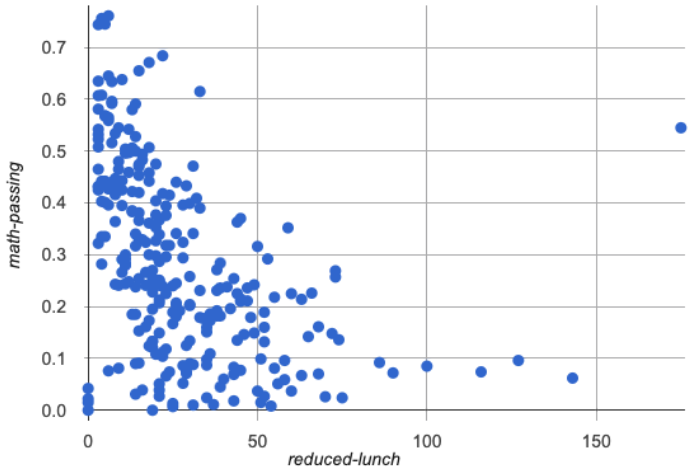
Describe two **histograms** made from columns of the animals dataset.
The first question is provided. You'll need to come up with the second question on your own!

Ask Questions 	*What is the distribution of weight among all animals at the shelter?* What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	The histogram I created is for _____ (x-variable in context) from _____ (dataset or subset). The shape of this histogram is _____ (skewed left, skewed right, symmetric). There are peaks at _____ and gaps at _____. I notice that _____ Consider statements like: Most of the histogram's area is… / A small amount of the histograms area trails out… / etc I wonder _____	

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	The histogram I created is for _____ (x-variable in context) from _____ (dataset or subset). The shape of this histogram is _____ (skewed left, skewed right, symmetric). There are peaks at _____ and gaps at _____. I notice that _____ Consider statements like: Most of the histogram's area is… / A small amount of the histograms area trails out… / etc I wonder _____	

Outliers: Should they Stay or Should they Go?

Tahli and Fernando are looking at a scatter plot showing the relationship between poverty and test scores at schools in Michigan. They find a trend, with low-poverty schools generally having higher test scores than high-poverty schools. However, one school is an extreme outlier: the highest poverty school in the state also has higher test scores than most of the other schools!



Tahli thinks the outlier should be removed before they start analyzing, and Fernando thinks it should stay. Here are their reasons:

Tahli's Reasons:	Fernando's Reasons:
This outlier is so far from every other school - it *has* to be a mistake. Maybe someone entered the poverty level or the test scores incorrectly! We don't want those errors to influence our analysis. Or maybe it's a magnet, exam or private school that gets all the top-performing students. It's not right to compare that to non-magnet schools.	Maybe it's not a mistake or a special school! Maybe the school has an amazing new strategy that's different from other schools! Instead of removing an inconvenient data point from the analysis, we should be focusing our analysis on what is happening there.

Do you think this outlier should stay or go? Why? What additional information might help you make your decision?

Measures of Center

There are three values used to report the *center* of a dataset .

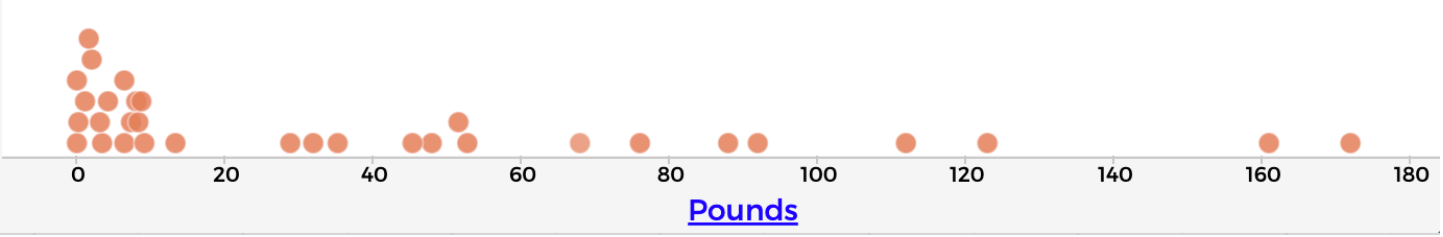
- Each of these measures of center summarizes a whole column of quantitative data using just one number:
  - The **mean** of a dataset is the average of all the numbers.
  - The **median** of a dataset is a value that is smaller than half the dataset, and larger than the other half. In an ordered list the median will either be the middle number or the average of the two middle numbers.
  - The **mode(s)** of a dataset is the value (or values) occurring most often. When all of the values occur equally often, a dataset has no mode.

Which Measure of Center is most typical, depends on the shape of the data and the number of values.

- *When a dataset is symmetric* , values are just as likely to occur a certain distance above the mean as below the mean, and the median and mean are usually close together.
- *When a dataset is asymmetric* , the median is a more decriptive measure of center than the median.
  - A dataset with **left skew** has a few values that are unusually low, which pull the mean *below* the median.
  - A dataset with **right skew** has a few values that are unusually high, which pull the mean *above* the median.
- When a dataset contains a small number of values, the mode may be the most descriptive measure of center. (Note that a small number of *values* is not the same as a small number of *data points* !)

What Value is Typical?

If we plotted all 32 animals' weights as points on a number line, it would look something like this:



1) What do you Notice?

2) What do you Wonder?

3) What do you think is a typical value in this sample? Why?

4) Identify another value someone might claim is typical in this sample. Why would they choose that value?

5) Do you think there is a midpoint of this sample? Why or why not?

6) Do you think there is a value that's repeated more than any other value? Why or why not?

Summarizing Columns with Measures of Center

Summarizing the `Pounds` Column

Find the measures of center to summarize the _____pounds_____ column of the Animals Starter File.

1) The three measures of center for this column are:

Mean (Average)	Median	Mode(s)

2) To take the average of a column, we add all the numbers in that column and divide by the number of rows. Will that work for every column?

_____

_____

3) The mean is _____ the median, which suggests the shape is _____.
(higher than/lower than/about equal to; skewed right (high outliers) / skewed left (low outliers) / symmetric)

4) Which do you think is the most useful measure for this column of data? Why? _____

_____

★ For which column(s) in the animals table do you think the modes might be a good measure of center? Why?

_____

Summarizing the _____ Column

Find the measures of center to summarize the _____ column of the Animals Starter File.
(a column of your choosing!)

The three measures of center for this column are:

Mean (Average)	Median	Mode(s)

The mean is _____ the median, which suggests the shape is _____.
(higher than/lower than/about equal to; skewed right (high outliers) / skewed left (low outliers) / symmetric)

★ Four animals weighing 5, 5, 10, and 100 pounds will have an average mean of 30 pounds.
(*because* $5 + 5 + 10 + 100 = 120$ *and* $120 \div 4 = 30$)

Can you think of another set of four animals that would have the same average? How many sets can you come up with?

_____

_____

_____

Critiquing Written Findings

Consider the following dataset, representing the heaviest bench press (in lbs) for ten powerlifters:

`135, 95, 230, 135, 203, 55, 1075, 135, 110, 185`

1) In the space below, rewrite this dataset in sorted order.

2) In the table below, compute the measures of center for this dataset.

Mean (Average)	Median	Mode(s)

3) The following statements are correct … but misleading. Write down the reason why.

Statement	Why it's misleading
"More personal records are set at 135 lbs than any other weight!"	
"The average powerlifter can bench press 235 lbs."	
"With a median of 135, that means that half the people in this group can't even lift 135 lbs."	

Data Cycle Practice

Open the Animals Starter File. Complete both of the Data Cycles shown here, which have questions defined to get you started.

Ask Questions 	*What is the mean age for cats at the shelter?* What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	If you only need some rows, write an expression for your Filter Transformer here. If you need to Transform or Build an attribute, write the expression for your Transformer here. What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	What did you find out? What can you infer? What - if any - new question(s) does this raise?	

Ask Questions 	*What is the median time it takes for an animal to be adopted?* What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	If you only need some rows, write an expression for your Filter Transformer here. If you need to Transform or Build an attribute, write the expression for your Transformer here. What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	What did you find out? What can you infer? What - if any - new question(s) does this raise?	

Data Cycle Practice

Open your chosen dataset. Complete both of the Data Cycles shown here.

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	If you only need some rows, write an expression for your Filter Transformer here. If you need to Transform or Build an attribute, write the expression for your Transformer here. What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	What did you find out? What can you infer? What - if any - new question(s) does this raise?	

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	If you only need some rows, write an expression for your Filter Transformer here. If you need to Transform or Build an attribute, write the expression for your Transformer here. What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	What did you find out? What can you infer? What - if any - new question(s) does this raise?	

Mean, Median, Mode(s) Practice

Mean

Find the mean of each dataset.

17, 23, 25, 23, 22	11, 3, 7, 4, 5	11, 3, 7, 4	5, 7, 11, 11, 7, 7	2, 3, 5, 4, 3, 7, 4

Median

Find the median of each dataset.

17, 23, 25, 23, 22	5, 11, 3, 7, 4	11, 3, 7, 4	5, 7, 11, 11, 7, 7	2, 3, 5, 4, 3, 7, 4

Mode(s)

Find the mode(s) of each dataset.

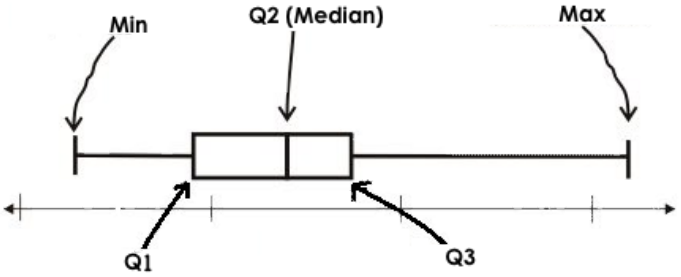
17, 23, 25, 23, 22	5, 11, 3, 7, 4	11, 3, 7, 4	5, 7, 11, 11, 7, 7	2, 3, 5, 4, 3, 7,4

Measures of Spread

Data Scientists measure the *spread* of a dataset using a *five-number summary*:

- ***Minimum***: the smallest value in a dataset - it starts the first quarter
- ***Q1 (lower quartile)***: the number that separates the first quarter of the data from the second quarter of the data
- ***Q2 (Median)*** : the middle value (median) in a dataset
- ***Q3 (upper quartile)***: the value that separates the third quarter of the data from the last
- ***Maximum***: the largest value in a dataset - it ends the fourth quarter of the data

The **five-number summary** can be used to draw a **box plot**.



- Each of the four sections of the box plot contains 25% of the data.
  - If the values are distributed evenly across the range, the four sections of the box plot will be equal in width.
  - Uneven distributions will show up as differently-sized sections of a box plot.
- The left **whisker** extends from the minimum to Q1.
- The **box**, or **interquartile range**, extends from Q1 to Q3. It is divided into 2 parts by the **median**. Each of those parts contains 25% of the data, so the whole box contains the central 50% of the data.
- The right **whisker** extends from Q3 to the maximum.

The box plot above, for example, tells us that:

- The minimum weight is about 165 pounds. The median weight is about 220 pounds. The maximum weight is about 310 pounds.
- The data is not evenly distributed across the range:
  - 1/4 of the players weigh roughly between 165 and 195 pounds
  - 1/4 of the players weigh roughly between 195 and 220 pounds
  - 1/4 of the players weigh roughly between 220 and 235 pounds
  - 1/4 of the players weigh roughly between 235 and 310 pounds
  - 50% of the players weigh roughly between 165 and 220 pounds
  - 50% of the players weigh roughly between 195 and 235 pounds
  - 50% of the players weigh roughly between 220 and 310 pounds
- The densest concentration of players' weights is between 220 and 235 pounds.
- Because the widest section of the box plot is between 235 and 310 pounds, we understand that the weights of the heaviest 25% fall across a wider span than the others.
  - 310 may be an outlier
  - the weights of the players weighing between 235 pounds 310 pounds could be evenly distributed across the range
  - or all of the players weighing over 235 pounds may weigh around 310 pounds.

Summarizing Columns with Measures of Spread

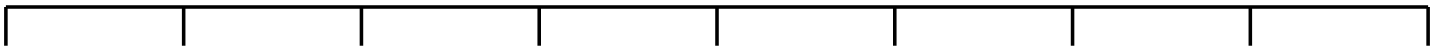
Summarizing the Pounds Column

Get the values to summarize the spread of the _____pounds_____ column of the Animals Starter File by creating a Box Plot and hovering over the minimum, Q1, median, Q3, and maximum.

1) My five-number summary is:

Minimum	Q1	Median	Q3	Maximum

2) Draw a box plot from this summary on the number line below. *Be sure to label the number line with consistent intervals.*



3) The **Range** is: _____ and the **Interquartile Range(IQR)** is: _____.

4) From this summary and box plot, I conclude that:

_____

_____

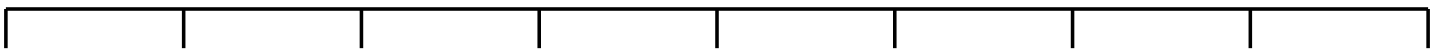
Summarizing the _____ Column

Choose another column to investigate by making a `box-plot`

5) My five-number summary is:

Minimum	Q1	Median	Q3	Maximum

6) Draw a box plot from this summary on the number line below. *Be sure to label the number line with consistent intervals.*



7) The **Range** is: _____ and the **Interquartile Range(IQR)** is: _____.

8) From this summary and box plot, I conclude that:

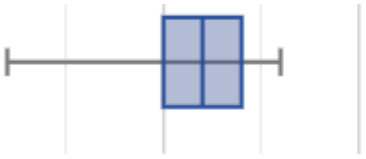
_____

_____

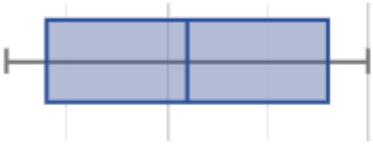
Identifying Shape - Box Plots

Describe the shape of the box plots on the left. *Do your best to incorporate the vocabulary you've been introduced to.*

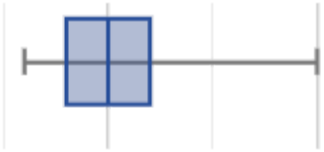
1



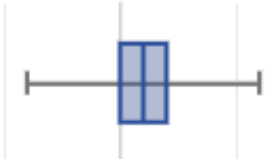
2



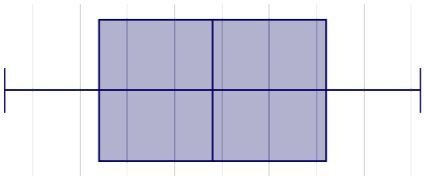
3



4

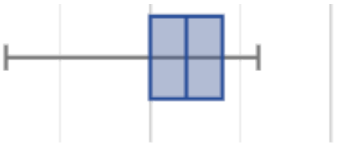


5



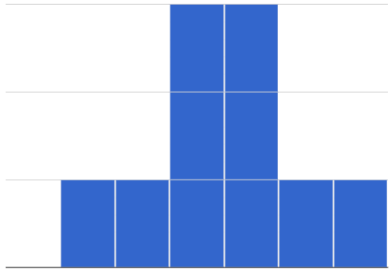
Matching Box Plots to Histograms

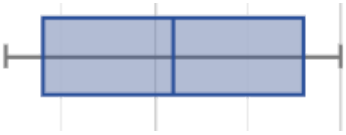
Students watched 5 videos, and rated them on a scale of 1 to 10. For each video, their ratings were used to generate box plots and histograms. Match each box plot to the histogram that displays the same data.



1

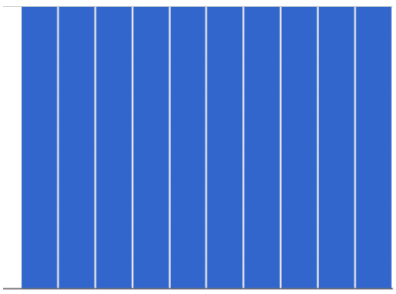
A

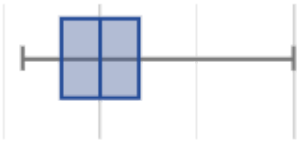




2

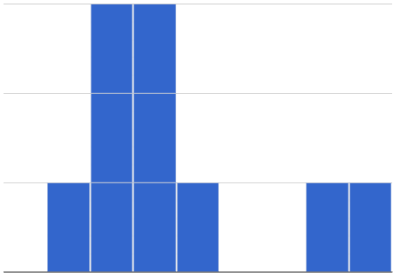
B

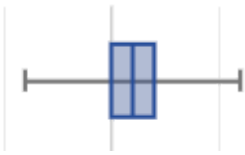




3

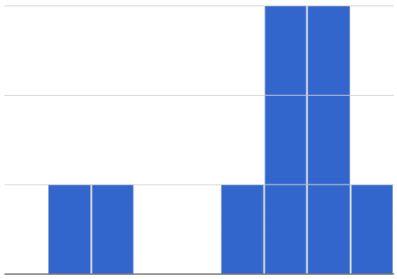
C

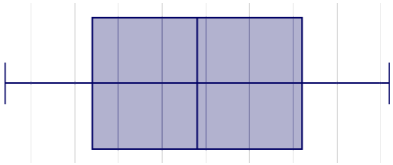




4

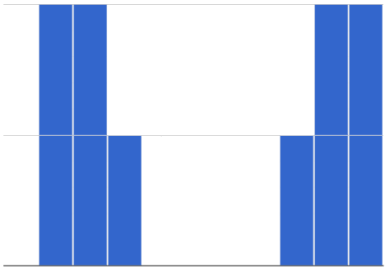
D





5

E



Directions: Connect each item on this page to at least one other item by drawing an arrow and writing an explanation of how they are connected along the arrow. (Arrows may curve.)

Minimum	Maximum	Quartile
Median	50%	Interquartile Range
Upper Quartile	Lower Quartile	25%

Data Cycle: Shape of the Animals Dataset

Open the Animals Starter File. Use the Data Cycle to explore the distribution of one or more quantitative columns using **box plots**.

Ask Questions

What is the distribution of the weeks column from the animals dataset?
What question do you have?

Question Type (circle one):
Lookup
Arithmetic
Statistical

Consider Data

Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.)

What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)

Analyze Data

What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?

Interpret Data

The box plot for _____ (x-variable in context) is _____ (skewed left / skewed right / symmetric / etc.).

The 5-number summary is: min = _____ Q1 = _____ median = _____ Q3 = _____ max = _____

The middle 50% of the data lies between _____ and _____ so the Interquartile Range is _____

I notice that _____
Consider statements like: 75% of the data fall below … / The top 25% of the data fall between … / etc

I wonder _____

Ask Questions

What question do you have?

Question Type (circle one):
Lookup
Arithmetic
Statistical

Consider Data

Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.)

What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)

Analyze Data

What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?

Interpret Data

The box plot for _____ (x-variable in context) is _____ (skewed left / skewed right / symmetric / etc.).

The 5-number summary is: min = _____ Q1 = _____ median = _____ Q3 = _____ max = _____

The middle 50% of the data lies between _____ and _____ so the Interquartile Range is _____

I notice that _____
Consider statements like: 75% of the data fall below … / The top 25% of the data fall between … / etc

I wonder _____

Data Cycle: Shape of My Dataset

Open your chosen dataset. Use the Data Cycle to explore the distribution of one or more quantitative columns using **box plots** , and write down your findings.

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	If you only need some rows, write an expression for your Filter Transformer here. If you need to Transform or Build an attribute, write the expression for your Transformer here. What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	What did you find out? What can you infer? What - if any - new question(s) does this raise?	

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	If you only need some rows, write an expression for your Filter Transformer here. If you need to Transform or Build an attribute, write the expression for your Transformer here. What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	What did you find out? What can you infer? What - if any - new question(s) does this raise?	

Distribution of a Dataset

Family Gatherings by the Numbers

Ledet Family Ages : 1, 44, 3, 42, 46, 74, 75, 21, 74, 70, 40, 41, 45 **Average:** 44.3 years old

1) Order the Ages from Least to Greatest: _____

Then compute: _____ Minimum _____ Q1 _____ Median _____ Q3 _____ Maximum _____ Range _____ Interquartile Range (IQR)

Watson Family Ages: 70, 68, 69, 72, 65, 75, 65, 78, 70, 72, 71, 70 **Average:** 70.4 years old

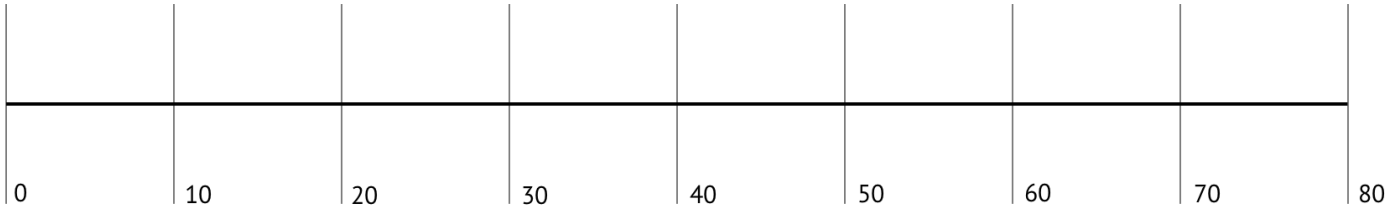
2) Order the Ages from Least to Greatest: _____

Then compute: _____ Minimum _____ Q1 _____ Median _____ Q3 _____ Maximum _____ Range _____ Interquartile Range (IQR)

Box Plots - Visualizing Shape

Make box plots to each family's age distribution on the number lines below. Hint: Plot the 5-Number Summaries, draw a box around the IQR (from Q1 to Q3), let the median split the box into 2 parts, and add whiskers from the box to the minimum and maximum values.

3) Ledet:



4) Watson:

Compare and Contrast

5) For which family gathering was the average age more typical? How do you know? _____

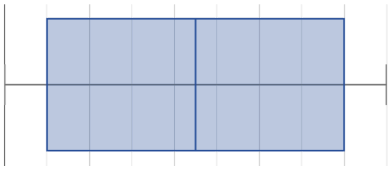
6) What else do you Notice and Wonder about the data from these two family gatherings?

7) We plotted both of these box plots on number lines with the same scale. What are the pros and cons of that choice?

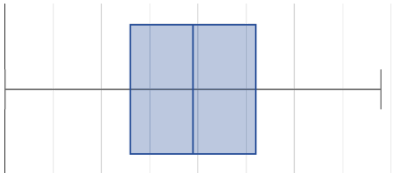
Reading Box Plots

A class of students took five different exams this year, and each distribution of their scores has been plotted in one of the five box plots below.

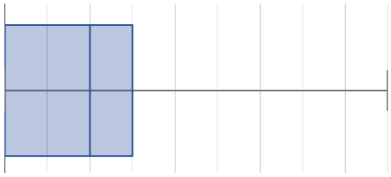
Match the summary description (left) with the *shape* of the box plot of student scores (right).



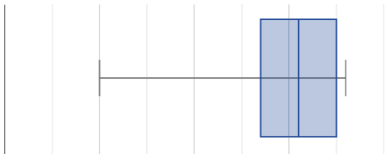
1



2



3



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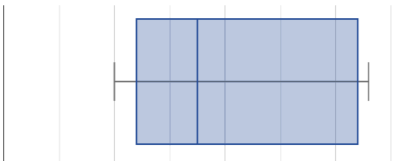


5

A Most students did pretty well on this exam, but there were some mediocre scores and a handful of very low scores.

B This exam featured one question worth a lot of points that many of the students got completely right, while many others got it completely wrong. Nobody actually got the "average" score.

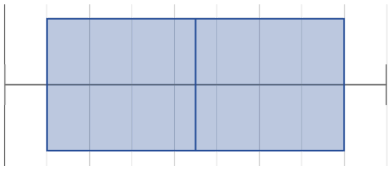
C A lot of students did poorly on this exam. Relatively few did just OK. Still, a bunch of students who really knew what they were doing completely aced it.

D Performance on this exam resulted in a classic "bell curve" shape: most students performed close to the average and scores far from the average in either direction were increasingly unlikely.

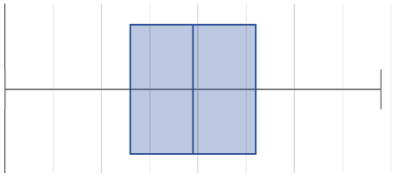
E This was a hard exam. Most students did poorly, with scores tapering to the point where hardly anyone got an A.

Matching Box Plots to Histograms 2

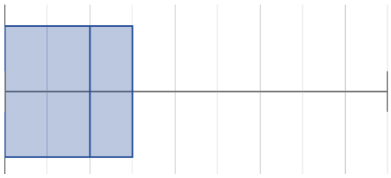
Match each box-plot to the histogram that displays the same data.



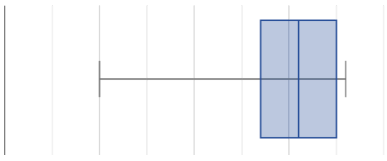
1



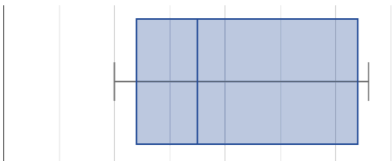
2



3

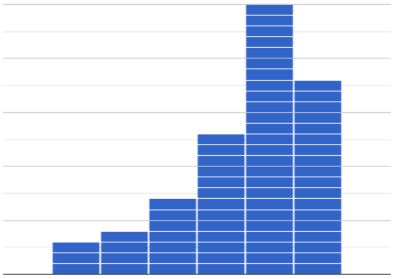


4

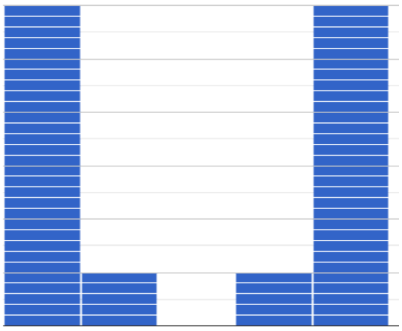


5

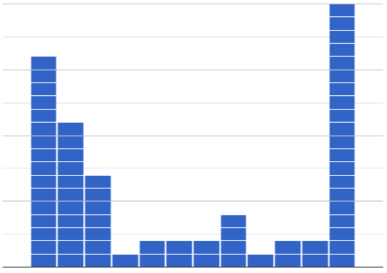
A



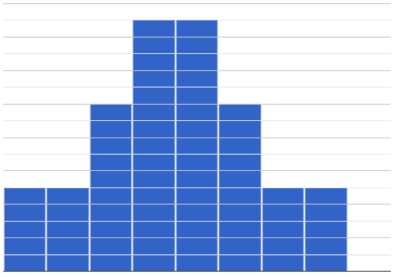
B



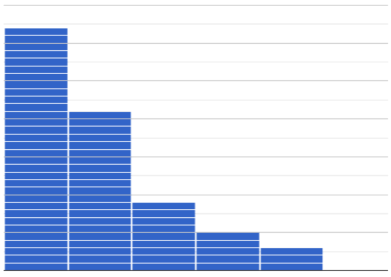
C



D



E

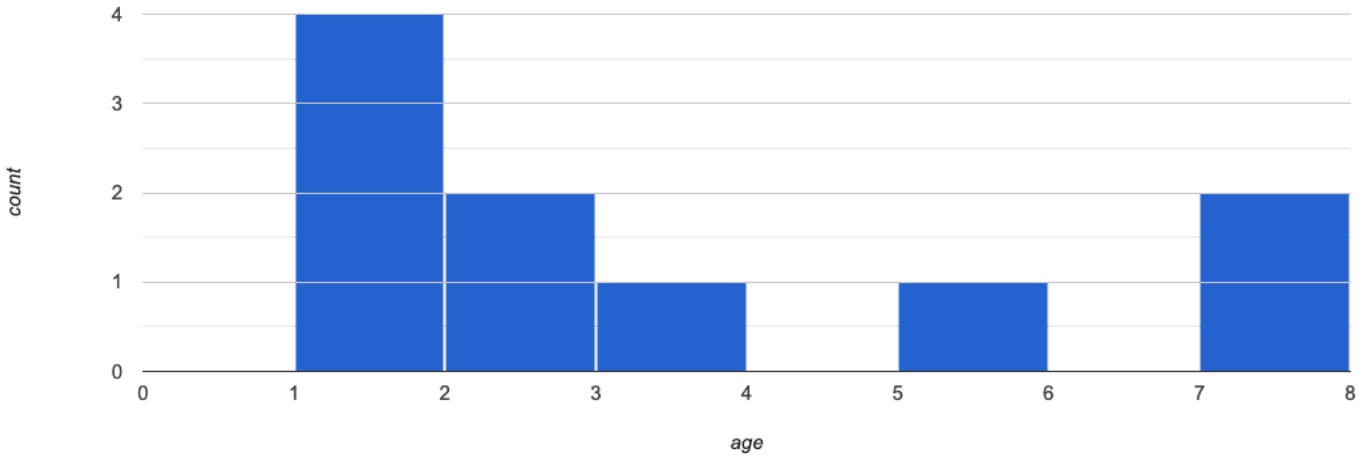


Computing Standard Deviation

Here are the ages of different cats at the shelter: *1, 7, 1, 1, 2, 2, 3, 1, 5, 7*

1) How many cats are represented in this sample? _____

The **distribution** of these ages is shown in the ***histogram*** below:



2) Describe the shape of this histogram. _____

3) What is the mean age of the cats in this dataset? _____

4) How many cats are 1 year old? 2 years old? Fill in the table below. The first column has been done for you.

age	1	2	3	4	5	6	7
count	4						

5) **Draw a star to locate the mean on the x-axis of the histogram above** .

6) For each cat in the histogram above, **draw a horizontal arrow** under the axis from your star to the cat's interval, and **label the arrow with its distance from the mean** . (For example, if the mean is 3 and a cat is in the 1yr interval, your arrow would stretch from 1 to 3, and be labeled with the distance "2")

To compute the standard deviation we square each distance and take the average, then take the square root of the average.

7) We've recorded the ages (N=10) shown in the histogram above in the table below, and listed the distance-from-mean for the four 1-year-old cats for you. As you can see, 1 year-olds are 2 years away from the mean, so their squared distance is 4. Complete the table.

age of cat	1	1	1	1	2	2	3	5	7	7
distance from mean	2	2	2	2						
squared distance	4	4	4	4						

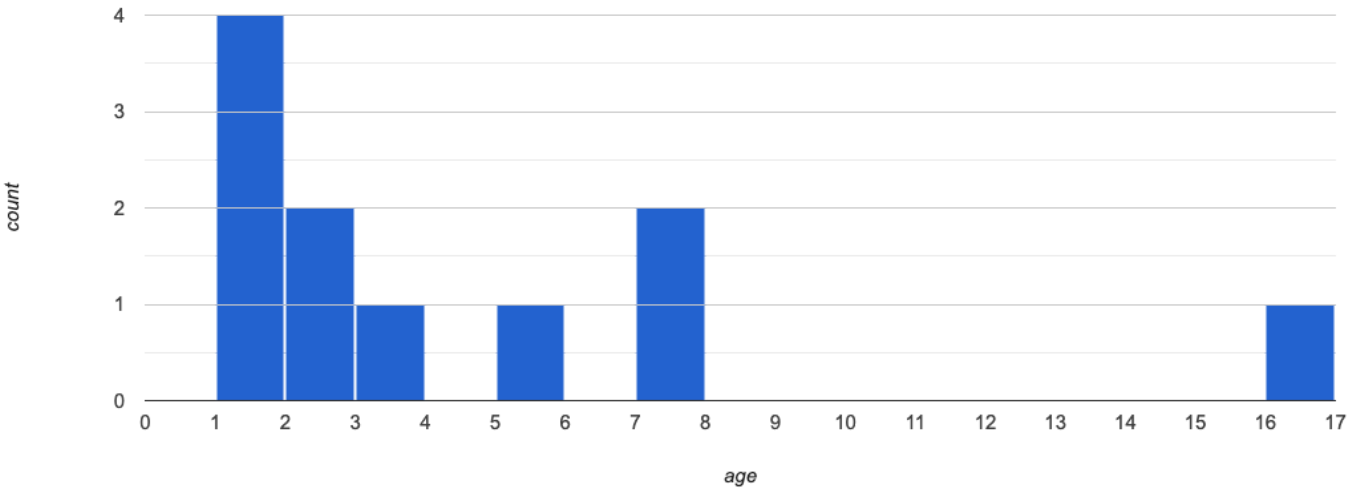
8) Add all the squared distances. What is their sum? _____

9) There are N=10 distances. What is N-1? _____ Divide the sum by *N-1* . What do you get? _____

10) Take the square root to find the **standard deviation** ! _____

The Effect of an Outlier

The histogram below shows the ages of eleven cats at the shelter:



1) Describe the shape of this histogram. _____

2) How many cats are 1 year old? 2 years old? Fill in the table below by reading the histogram. The first column has been done for you.

age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
count	4															

3) What is the mean age of the cats in this histogram? _____

4) **Draw a star to identify the mean on the histogram above** .

5) For each cat in the histogram above, **draw a horizontal arrow** from the mean to the cat's interval, and **label the arrow with its distance from the mean** . (For example, if the mean is 2 and a cat is 5 years old, your arrow would stretch from 2 to 5, and be labeled with the distance "3")
To compute the standard deviation we square each distance and take the average, then take the square root of the average.

6) Recorded the 11 ages shown in the histogram in the first row of the table below. For each age, compute the distance from the mean and the squared distance.

age of cat											
distance from mean											
squared distance											

7) Add all the squared distances. What is their sum? _____

8) Divide the sum by *N-1* . What do you get? _____

9) Take the square root to find the **standard deviation** ! _____

10) How did the outlier impact the standard deviation? _____

_____

Data Cycle: Standard Deviation in the Animals Dataset

Open the Animals Starter File. The mean time-to-adoption is 5.75 weeks. Does that mean most animals generally get adopted in 4-6 weeks? Use the Data Cycle to find out. Write your findings on the lines below, in response to the question.

Ask Questions 	*Do the animals all get adopted in around the same length of time?* What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	If you only need some rows, write an expression for your Filter Transformer here. If you need to Transform or Build an attribute, write the expression for your Transformer here. What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	What did you find out? What can you infer? What - if any - new question(s) does this raise?	

Turn the Data Cycle above into a Data Story, which answers the question *"If the average adoption time is 5.75 weeks, do all the animals get adopted in roughly 4-6 weeks?"*

Data Cycle: Standard Deviation in My Dataset

Open your chosen dataset. Use the Data Cycle to find the standard deviation in two distributions, and write down your thinking and findings.

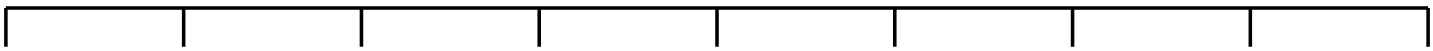
Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	If you only need some rows, write an expression for your Filter Transformer here. If you need to Transform or Build an attribute, write the expression for your Transformer here. What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	What did you find out? What can you infer? What - if any - new question(s) does this raise?	

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	If you only need some rows, write an expression for your Filter Transformer here. If you need to Transform or Build an attribute, write the expression for your Transformer here. What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	What did you find out? What can you infer? What - if any - new question(s) does this raise?	

Computing Standard Deviation (2)

Here are ten different family incomes: *$43k, $62k, $39k, $141k, $58k, $82k, $41k, $73k, $68k, $73k*

1) Draw the **distribution** of these incomes by placing a dot on the number line below. If two families have the same income, put one dot on top of the other. Finally, draw a ***box plot*** on the number line, making sure to label the axis and show each quartile.



2) Describe the shape of this box-plot. _____

3) What is the mean income of the families in this dataset? _____

4) How many families earn $39k? $43k? Fill in the table below. The first column has been done for you.

income	$39k	$41k	$43k	$58k	$62k	$68k	$73k
$82k	$141k	count	1				

5) **Draw a star to locate the mean on the number line above** .

6) For each family on the number line you drew,

- **Draw a horizontal arrow** under the axis from the star you drew in #5 to the dot for that family's income
- **Label the arrow with its distance from the mean** .
  e.g. if the mean is $50k and a family's income is $82k, your arrow would stretch from $50k to $82k, and be labeled with the distance "$32k"

To compute the standard deviation we square each distance and take the average, then take the square root of the average.

7) For each of the 10 incomes in the table below, list the distance-from-mean for each income, using the mean you computed above. Then fill in the squared distance in the next row to complete the table.

income (in 10s of thousands)	39	41	43	58	62	68	73	73	82	141
distance from mean										
squared distance										

8) Add all the squared distances. What is their sum? _____

9) There are N=10 distances. What is N-1? _____ Divide the sum by *N-1* . What do you get? _____

10) Take the square root to find the **standard deviation** ! _____

Matching Mean & Standard Deviation to Data

In the table below, match the mean and standard deviation to the list of data it describes.

Mean: 4 *StDev:* 0	**1**	**A**	`−1,−2,−3,−4,−5,−6,−7`
Mean: -5 *StDev:* ~5.66	**2**	**B**	`1, 2, 3, 4, 5, 6, 7`
Mean: 4 *StDev:* ~2.16	**3**	**C**	`−1, −9`
Mean: 4 *StDev:* ~2.65	**4**	**D**	`0, 2, 3, 4, 5, 6, 8`
Mean: -4 *StDev:* ~2.16	**5**	**E**	`4, 4, 4, 4, 4`

Correlations in Scatter Plots

Scatter Plots **can be used to show a relationship between two quantitative columns.**
Each row in the dataset is represented by a point, with one column providing the x-value and the other providing the y-value . The resulting "point cloud" makes it possible to look for a relationship between those two columns.

- *Form*
  - If the points in a scatter plot appear to follow a straight line, it suggests that a ***linear relationship*** exists between those two columns.
  - Relationships may take other forms (u-shaped for example). If they aren't linear, it won't make sense to look for a correlation.
  - Sometimes there will be no relationship at all between two variables.

Line of Best Fit
We graphically summarize a relationship by drawing a straight line through the data cloud, so that the vertical distance between the line and all the points taken together is as small as possible. This allows us to predict y-values (the ***response variable***) based on x-values (the ***explanatory variable***).

- *Direction*
  - The correlation is **positive** if the point cloud slopes up as it goes farther to the right. This means larger y-values tend to go with larger x-values.
  - The correlation is **negative** if the point cloud slopes down as it goes farther to the right.
- *Strength*
  - It is a **strong** correlation if the points are tightly clustered around a line. In this case, knowing the x-value gives us a pretty good idea of the y-value.
  - It is a **weak** correlation if the points are loosely scattered and the y-value doesn't depend much on the x-value.

Points that do not fit the trend line in a scatter plot are called **unusual observations** .

r-value
We can summarize the ***correlation*** between two quantitative columns in a single number.

- The r-value will always fall between −1 and +1.
- The sign tells us whether the correlation is positive or negative.
- Distance from 0 tells us the strength of the correlation.
- Here is how we might interperet some specific r-values:
  - −1 is the strongest possible negative correlation.
  - +1 is the strongest possible positive correlation.
  - 0 means no correlation.
  - ±0.65 or ±0.70 or more is typically considered a "strong correlation".
  - ±0.35 to ±0.65 is typically considered "moderately correlated".
  - Anything less than about ±0.25 or ±0.35 may be considered weak.

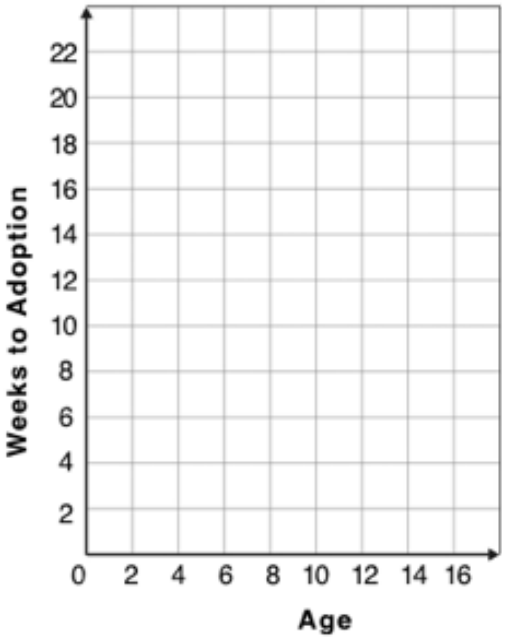
Note: These cutoffs are not an exact science! In some contexts an r-value of ±0.50 might be considered impressively strong!

Correlation is not causation! Correlation only suggests that two column variables are related, but does not tell us if one causes the other. For example, hot days are correlated with people running their air conditioners, but air conditioners do not cause hot days!

Creating a Scatter Plot

1) The table below has some new animals!
Choose one and *(paying careful attention to how the axes are labelled)*
plot their age/weeks values by adding a dot to the scatter plot on the right.
Then write the animal's name next to the dot you made.

name	species	age	weeks
"Alice"	"cat"	1	3
"Bob"	"dog"	11	5
"Callie"	"cat"	16	4
"Diver"	"lizard"	2	24
"Eddie"	"dog"	6	9
"Fuzzy"	"cat"	1	2
"Gary"	"rabbit"	6	12
"Hazel"	"dog"	3	2



2) Plot the rest of the animals - one at a time - labeling each point as you go. After each animal, ask yourself whether or not you see a pattern in the data.

3) After how many animals did you begin to see a pattern? _____

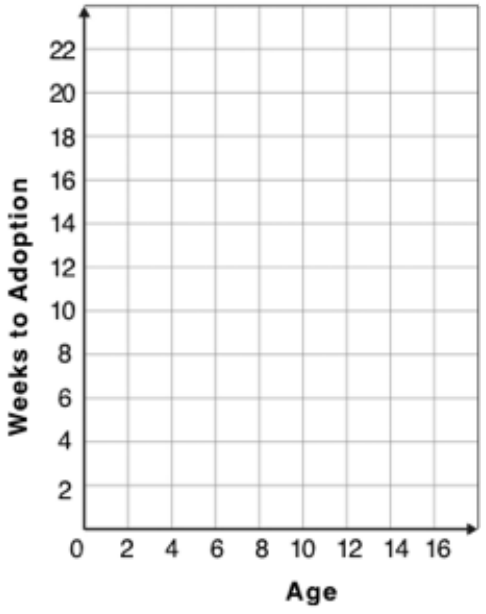
4) Use a straight edge to draw a line on the graph that best represents the pattern you see, then circle the cloud of points around that line.

5) Are the points tightly clustered around the line or loosely scattered? _____

6) Does this display support the claim that younger animals get adopted faster? Why or why not?

_____

7) Place points on the graph to create a scatter plot with NO relationship.



Exploring Relationships Between Columns

This page is designed to be used with the Animals Starter File. Log into CODAP to open your saved copy.

As you consider each of the following relationships, first think about what you *expect* , then make the scatter plot to see if it supports your hunch.

1) How are the `pounds` an animal weighs related to its `age`?

- What would you expect? _____

_____

- What did you learn from your scatter plot? _____

_____

2) How are the number of `weeks` it takes for an animal to be adopted related to its number of `legs`?

- What would you expect? _____

_____

- What did you learn from your scatter plot? _____

_____

3) How are the number of `legs` an animal has related to its `age`?

- What would you expect? _____

_____

- What did you learn from your scatter plot? _____

_____

4) Do any of these relationships appear to be linear (straight-line)?

_____

_____

5) Are there any unusual observations?

_____

_____

_____

_____

Data Cycle: Relationships in the Animals Dataset

Open the Animals Starter File. Use the Data Cycle to search for relationships between columns. *The first cycle has a question to get you started. What question will you ask for the second?*

Ask Questions 	*Is there a relationship between weight and adoption time?* What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	What did you find out? What can you infer? What - if any - new question(s) does this raise?	

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
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Analyze Data 	What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	What did you find out? What can you infer? What - if any - new question(s) does this raise?	

Data Cycle: Relationships in Your Dataset

Open your chosen dataset. Use the Data Cycle to search for relationships between columns.

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	❏ There appears to be no relationship between _____ (x-variable) and _____ (y-variable). ❏ There appears to be a _____ (strong / weak / moderate), _____ (positive / negative), _____ (linear / non-linear) relationship between _____ (x-variable) and _____ (y-variable). Some possible outliers might be _____	

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
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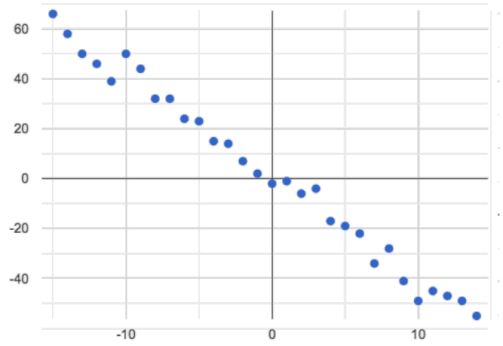
Identifying Form, Direction and Strength

What do your eyes tell you about the Form, Direction, & Strength of these displays?

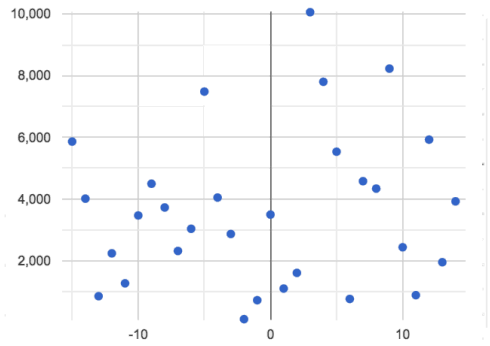
Note: If the form is nonlinear, we shouldn't report direction - a curve may rise and then fall.

A



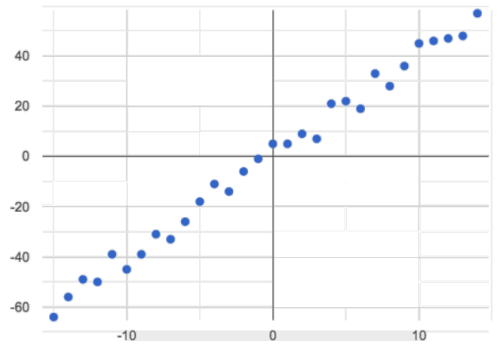
Form:	Linear	Nonlinear	None
Direction:	Positive	Negative	N/A
Strength:	Strong	Weak	

B



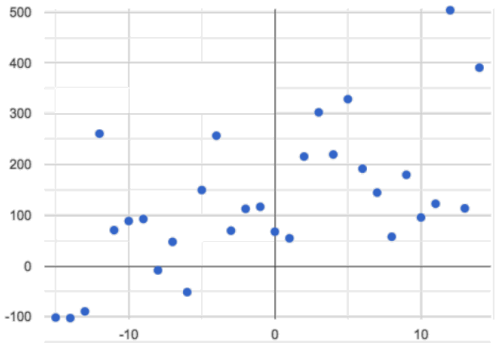
Form:	Linear	Nonlinear	None
Direction:	Positive	Negative	N/A
Strength:	Strong	Weak	

C



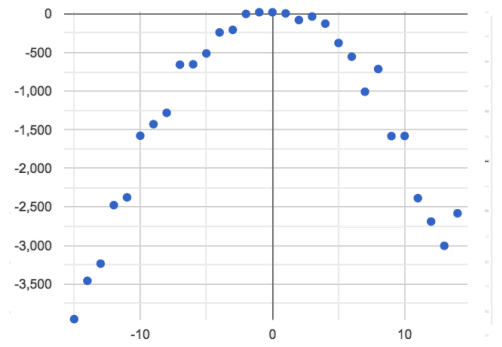
Form:	Linear	Nonlinear	None
Direction:	Positive	Negative	N/A
Strength:	Strong	Weak	

D



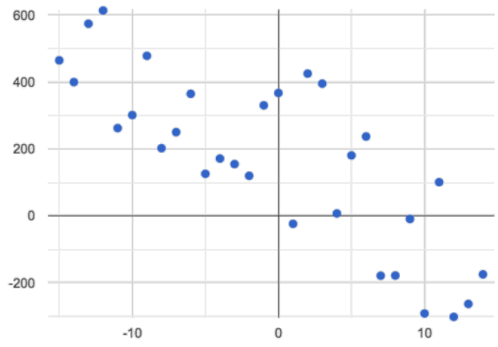
Form:	Linear	Nonlinear	None
Direction:	Positive	Negative	N/A
Strength:	Strong	Weak	

E



Form:	Linear	Nonlinear	None
Direction:	Positive	Negative	N/A
Strength:	Strong	Weak	

F



Form:	Linear	Nonlinear	None
Direction:	Positive	Negative	N/A
Strength:	Strong	Weak	

Reflection on Form, Direction and Strength

1) What has to be true about the *shape* of a relationship in order to start talking about the correlation's *direction* being positive or negative?

2) What is the difference between a *weak* relationship and a *negative* relationship?

3) What is the difference between a *strong* relationship and a *positive* relationship?

4) If we find a strong relationship in a sample from a larger population, will that relationship *always hold* for the whole population? Why or why not?

5) If two correlations are both positive, is the stronger one *more positive* (steeper slope) than the other?

6) A news report claims that after surveying *10 million people*, a positive correlation was found between how much chocolate a person eats and how happy they are. Does this mean eating chocolate almost certainly makes you happier? Why or why not?

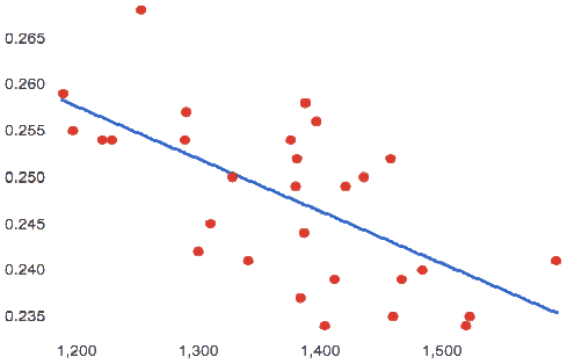
Identifying Form and r-Values

What do your eyes tell you about the Form and Direction of the data? If the form is linear, approximate the r-value.

Reminder:

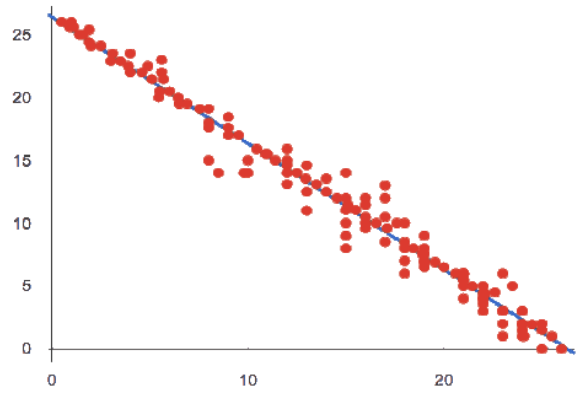
- −1 is the strongest possible *negative* correlation, and +1 is the strongest possible *positive* correlation
- 0 means no correlation
- ±0.65 or ±0.70 or more is typically considered a "strong correlation"
- ±0.35 to ±0.65 is typically considered "moderately correlated"
- Anything less than about ±0.25 or ±0.35 may be considered weak

A



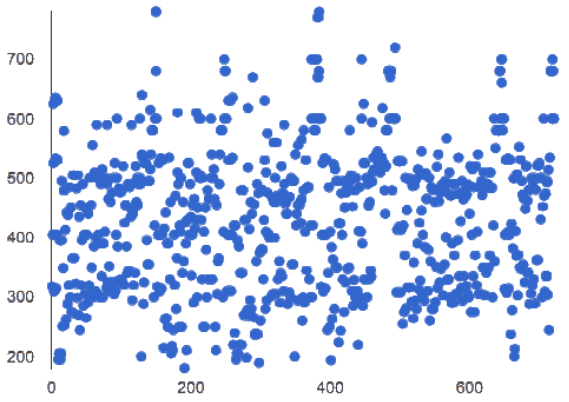
Form :
r close to :

B



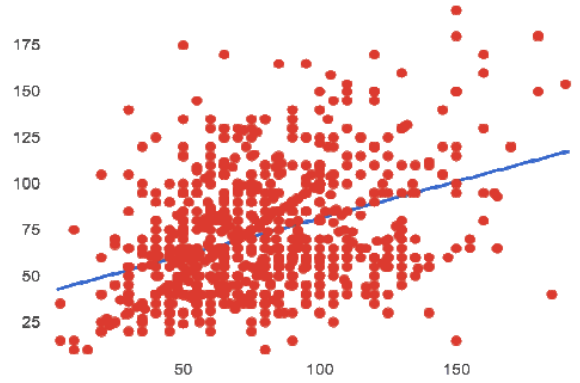
Form :
r close to :

C



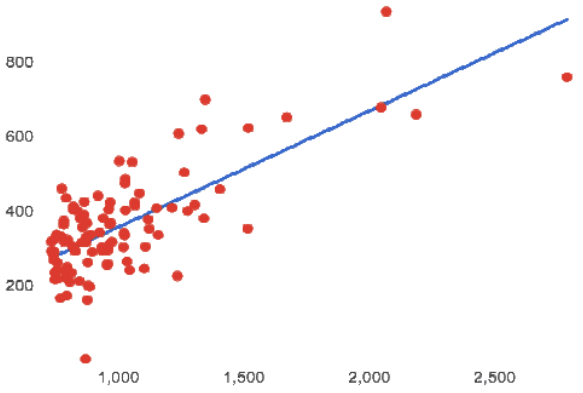
Form :
r close to :

D



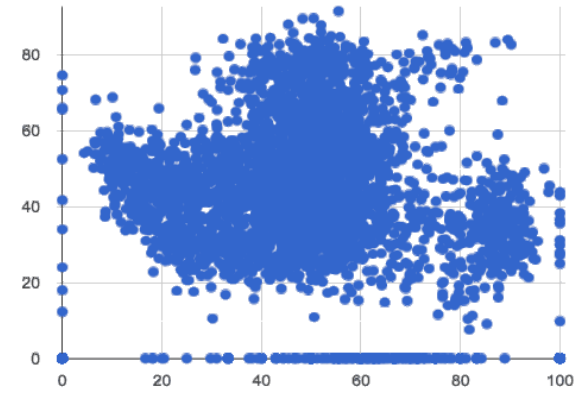
Form :
r close to :

E



Form :
r close to :

F



Form :
r close to :

Correlation Does Not Imply Causation!

Here are some possible correlations and the nonsense headlines a confused journalist might report as a result. In reality, the correlations have absolutely no causal relationship; they come about because both of them are related to another variable that's lurking in the background.

Can you think of another variable for each situation that might be the actual cause of the correlation and explain why the headlines the paper ran based on the correlations are nonsense?

1) **Correlation:** For a certain psychology test, the amount of time a student studied was negatively correlated with their score!
Headline: "Students who study less do better!"

2) **Correlation:** Weekly data gathered at a popular beach throughout the year showed a positive correlation between sunburns and shark attacks.
Headline: "Sunburns Attract Shark Attacks!"

3) **Correlation:** A negative correlation was found between rain and ski accidents.
Headline: "Be Safe - Ski in the Rain!"

4) **Correlation:** Medical records show a positive correlation between Tylenol use and Death Rates.
Headline: "Tylenol use increases likelihood of dying!"

5) **Correlation:** A positive correlation was found between hot cocoa sales and snow ball fights.
Headline: "Beware: Hot Cocoa Drinking encourages Snow Throwing!"

Correlations in the Animals Dataset

1) Create a scatter plot for the Animals Starter File, using `"pounds"` as the xs and `"weeks"` as the ys.

- **Form:** Does the point cloud appear linear or nonlinear? _____
- **Direction:** If it's linear, does it appear to go up or down as you move from left to right? _____
- **Strength:** Is the point cloud tightly packed, or loosely dispersed? _____
- Would you predict that the r-value is positive or negative? _____
- Will it be closer to zero, closer to ±1, or in between? _____
- What r-value, does CODAP compute when you type `r-value(animals-table, "pounds", "weeks")`? _____
- Does this match your predictions? _____

_____

_____

2) Create a scatter plot for the Animals Dataset, using `"age"` as the xs and `"weeks"` as the ys.

- **Form:** Does the point cloud appear linear or nonlinear? _____
- **Direction:** If it's linear, does it appear to go up or down as you move from left to right? _____
- **Strength:** Is the point cloud tightly packed, or loosely dispersed? _____
- Would you predict that the r-value is positive or negative? _____
- Will it be closer to zero, closer to ±1, or in between? _____
- What r-value does CODAP compute? _____
- Does this match your prediction? _____

3) Is this correlation **stronger** or **weaker** than the correlation for `"pounds"`? _____

4) What does that *mean*? _____

_____

_____

_____

Correlations in My Dataset

1) There may be a correlation between _____ (column) and _____ (column).

I think it is a _____ (strong/weak), _____ (positive/negative) correlation,

because _____

It might be stronger if I looked at _____ (a sample or extension of my data)

---

2) There may be a correlation between _____ (column) and _____ (column).

I think it is a _____ (strong/weak), _____ (positive/negative) correlation,

because _____

It might be stronger if I looked at _____ (a sample or extension of my data)

---

3) There may be a correlation between _____ (column) and _____ (column).

I think it is a _____ (strong/weak), _____ (positive/negative) correlation,

because _____

It might be stronger if I looked at _____ (a sample or extension of my data)

---

4) There may be a correlation between _____ (column) and _____ (column).

I think it is a _____ (strong/weak), _____ (positive/negative) correlation,

because _____

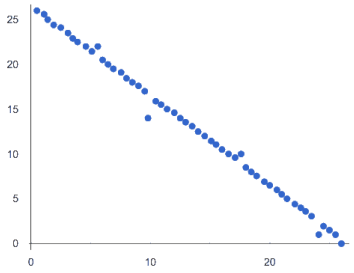
It might be stronger if I looked at _____ (a sample or extension of my data)

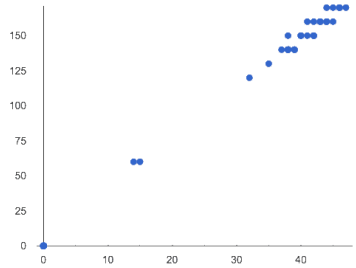
Identifying Form, Direction and Strength (Matching)

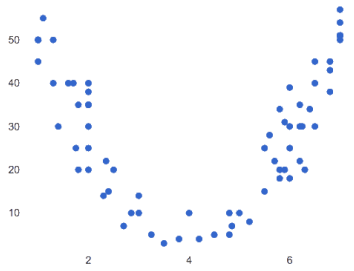
Match the description (left) with the scatter plot (right).

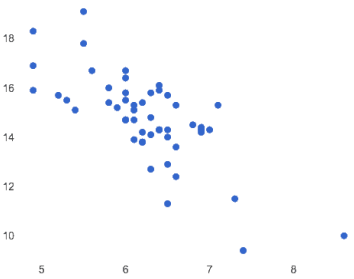
Note: The computer won't tell us if the relationship we see in a scatter plot is linear, so it's important to train our eyes to decide this ourselves. For linear relationships, we should train our eyes to assess their direction and get a feel for their strength, so that we have a sense of whether the computed results make sense.

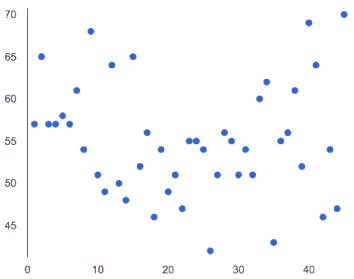
The relationship appears to be linear, negative, and of moderate strength.	1	A
This relationship is nonlinear.	2	B
The x and y variables in this dataset do not appear to be related.	3	C
The relationship appears to be linear, positive, and strong.	4	D
The relationship appears to be linear, negative, and strong.	5	E











Linear Regression

- **We compute linear relationships to predict the future!** Well…sort of. Given a dataset, like ages of animals v. how long before they're adopted, we try to compute the relationship between `age` and `weeks` so that we can *predict* how long a new animal might stay, based on their age.
- When we compute linear relationships, we're talking about **straight-line patterns** that appear on a scatter plot.
- A scatter plot has an x-axis and a y-axis. When looking for relationships, the y-axis is called the ***response variable***, and the x-axis is called the ***explanatory variable***. In our example, we are trying to figure out how much of the `weeks` variable is *explained by* the `age` variable.
- **Linear Regression** is a way of computing the **line of best fit**, which tries to draw a line as close as possible to all the points. (Want details? It minimizes the *sum of the squares* of the vertical distances from the points to the line. There's a reason we use computers to do this!)
- **Slope** is how much we predict the ***response variable*** will increase or decrease for each unit that the ***explanatory variable*** increases. In our example, a slope of 0.5 would mean "we predict that each additional year of age means an extra half-week in the shelter". (What would a slope of 3 mean?)
- **Sample size matters!** The number of data values is also relevant. We'd be more convinced of a positive relationship in general between cat age and time to adoption if a correlation of +0.57 were based on 50 cats instead of 5.

Introduction to Linear Regression

How much can one point move the line of best fit?

Open the Interactive Regression Line (Geogebra). Move the blue point "P", and see what effect it has on the red line.

1) Move P so that it is **centered amongst** the other points. Now move it all the way to top and bottom of the screen.

2) Move P so that it is **far to the left or right** of the other points. Now move it all the way to top and bottom of the screen. How - if at all - does the x-position of P impact on the line of best fit? _____

_____

3) Could the ***regression line*** ever be above or below *all* the points *(including the blue one you're dragging)*? Why or why not? _____

_____

4) Would it be possible to have a line with more points on one side than the other? Why or why not? _____

_____

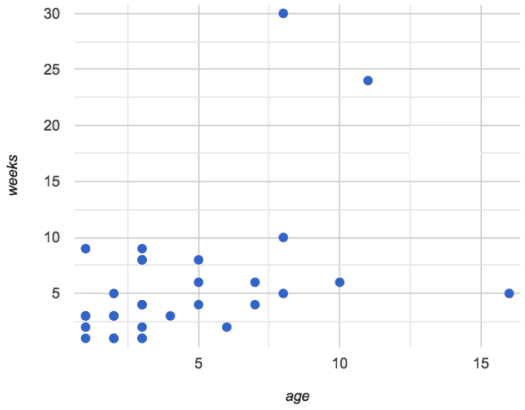
5) What is the highest r-value you can get? _____ Where did you place P? (_____, _____)

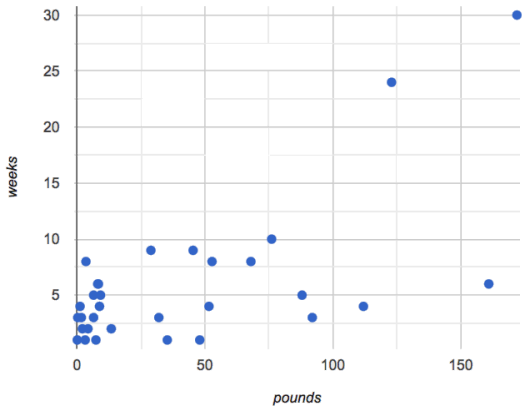
6) What function describes the regression line with this value of P? $y =$ _____ $x +$ _____

7) What is the lowest r-value you can get? _____ Where did you place P? (_____, _____)

8) What function describes the regression line with this value of P? $y =$ _____ $x +$ _____

Predictions from Scatter Plots





9) Draw the line of best fit for age-v-weeks (on the left). Is this a strong correlation that will allow us to make a good prediction of an animal's adoption time just by knowing how old it is?

_____

10) Draw the line of best fit for pounds-v-weeks (on the right). Is this a strong correlation that will allow us to make a good prediction of an animal's adoption time just by knowing how heavy it is?

_____

11) Do either or both of the relationships appear to be linear?

_____

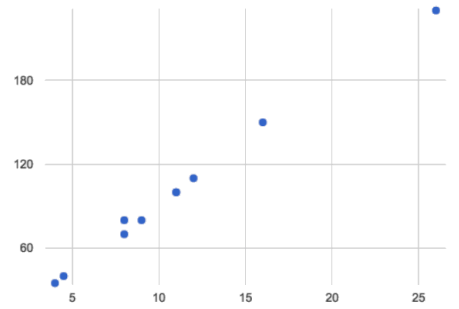
Drawing Predictors

Remember what we learned about r-values…

r = -1	r = -0.5	r = 0	r = 0.5	r = 1
perfect negative correlation	moderate negative association	no correlation	moderate positive association	perfect positive correlation

For each of the scatter plots below, draw a **predictor line** that seems like the best fit. Describe the correlation in terms of Direction and whether you think it is **generally** *stronger* or *weaker*, then estimate the r-value as being close to -1, -0.5, 0, +0.5, or +1.

A

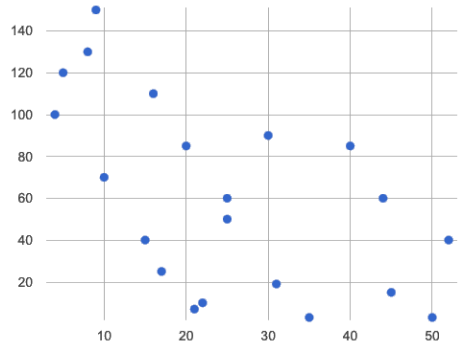


Direction: Positive Negative None

Strength: Stronger Weaker

estimated **r**: -1 -0.5 0 0.5 1

B

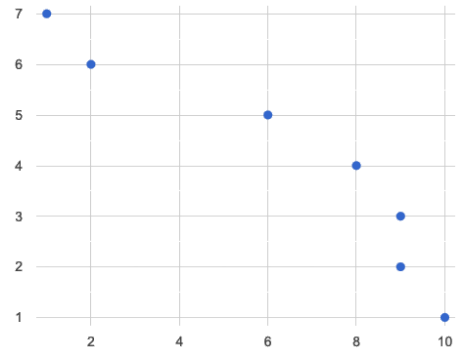


Direction: Positive Negative None

Strength: Stronger Weaker

estimated **r**: -1 -0.5 0 0.5 1

C

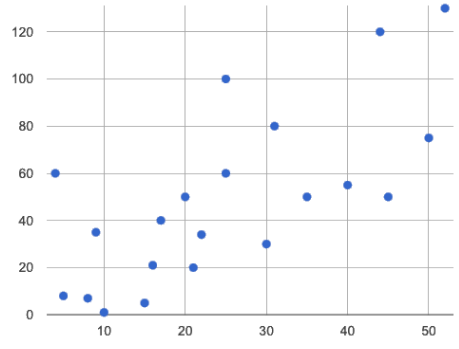


Direction: Positive Negative None

Strength: Stronger Weaker

estimated **r**: -1 -0.5 0 0.5 1

D



Direction: Positive Negative None

Strength: Stronger Weaker

estimated **r**: -1 -0.5 0 0.5 1

Exploring lr-plot

age

You should already have created a Least Squares line with `Weeks` *on the x-axis and* `Age` *on the y-axis in the Animals Starter File.*

1) What is the predictor function? $y =$ _____ $x +$ _____

2) What is the slope? _____

3) What is the y-intercept? _____

4) How long would our line of best fit predict it would take for a 5 year-old animal to be adopted? _____

5) What if they were a newborn, or just 0 years old? _____

6) Does it make sense to find the adoption time for a newborn using this predictor function? Why or why not?

_____

weight

Make another Least Squares Line, but this time use the animals' weight as our explanatory variable instead of their age.

7) How long would our line of best fit predict it would take for an animal weighing 21 pounds to be adopted? _____

8) What if they weighed 0.1 pounds? _____

cats

9) Using the Animals Dataset - Cats Only, make another Least Squares Line, comparing the `age` v. `weeks` columns for *only the cats*.

10) What is the predictor function? $y =$ _____ $x +$ _____

11) What is the slope? _____

12) What is the y-intercept? _____

13) How does this line of best fit for *cats* compare to the line of best fit for *all animals*? _____

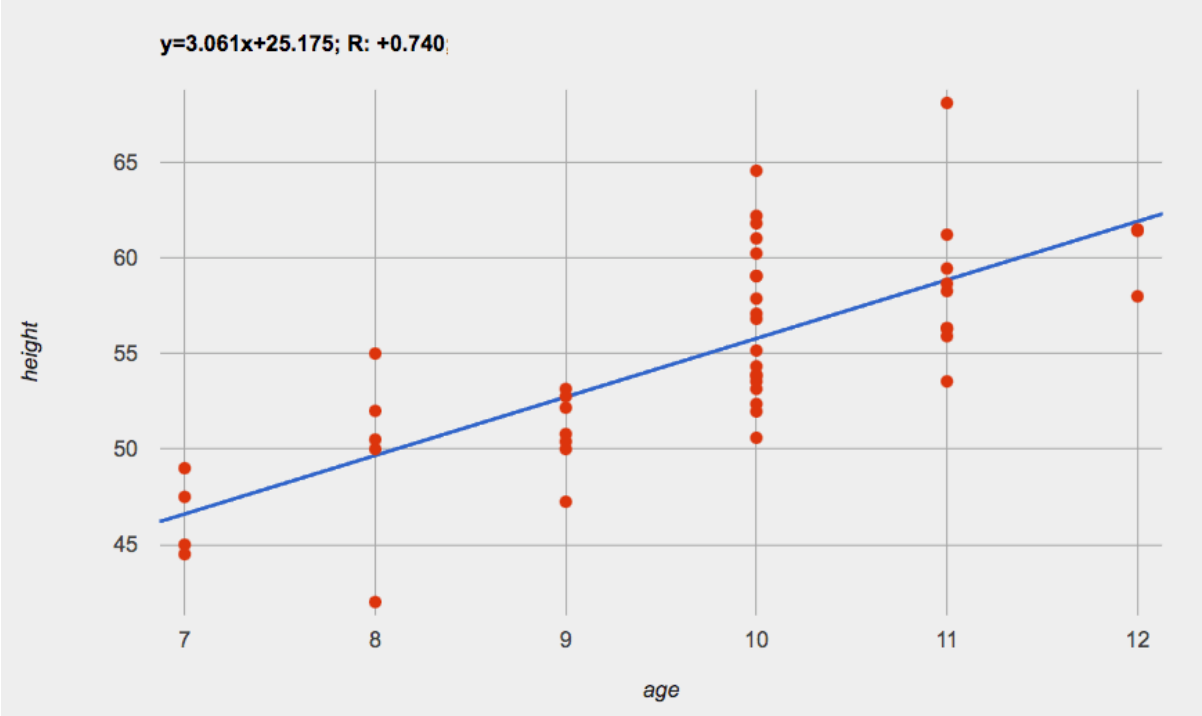
_____

_____

14) How long would our line of best fit predict it would take for a 5 year-old cat to be adopted? _____

★ Using Animals Dataset - Dogs Only, make another Least Squares line, comparing the `age` v. `weeks` columns for *only the dogs*.

Making Predictions



1) About how many inches are kids in this dataset expected to grow per year? _____

2) At that rate, if a child were 45" tall at age eight, how tall would you expect them to be at age twelve? _____

3) At that rate, if a ten-year-old were 55" tall, how tall would you expect them to have been at age 9? _____

4) Using the equation, how tall would you expect a seven-year-old child to be? _____

5) How many of the seven-year-olds in this sample are actually that height? _____

6) Using the equation, determine the expected height of someone who is…

7.5 years old	13 years old	6 years old	newborn	90 years old

7) For which ages is this predictor function likely to be the **most** accurate? Why? _____

_____

_____

8) For which ages is this predictor function likely to be the **least** accurate? Why? _____

_____

_____

Interpreting Regression Lines & r-Values

Use the predictor function and r-value from each linear regression finding on the left to fill in the blanks of the corresponding description on the right.

1	`sugar(m) = −3.19m + 12` `r = −0.05`	For every additional Marvel Universe movie released each year, the average person is predicted to consume _____ [amount] _____ [more / fewer] pounds of sugar! This correlation is _____ [strong, moderate, weak, practically non-existent].
2	`height(s) = 1.65s + 52` `r = 0.89`	Shoe size and height are _____ [strongly, moderately, weakly, not], _____ [positively / negatively] correlated. If person A is one size bigger than person B, we predict that they will be roughly _____ [amount] inches taller than person B as well.
3	`babies(u) = 0.012u + 7.8` `r = 0.01`	There is _____ [a strong, a moderate, almost no] relationship found between the number of Uber drivers in a city and the number of babies born each year.
4	`score(w) = −15.3w + 1150` `r = −0.65`	The correlation between weeks-of-school-missed and SAT score is _____ [strong, moderate, weak, practically non-existent] and _____ [positive / negative]. For every week a student misses, we predict a _____ [amount] point _____ [gain / drop] in their SAT score.
5	`weight(n) = 1.6n + 160` `r = 0.12`	There is a _____ [strong, moderate, weak, practically non-existent], _____ [positive / negative] correlation between the number of streaming video services someone has, and how much they weigh. For each service, we expect them to be roughly _____ [amount] pounds heavier.

Data Cycle: Animals Regression Analysis

Open the Animals Starter File. Before completing a data cycle on your own, read the provided example.

Ask Questions

How big of a factor is age in determining adoption time?
What question do you have?

Question Type (circle one):
Lookup
Arithmetic
Statistical

Consider Data

all animals at the shelter
Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.)

name, age, and weeks
What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)

Analyze Data

Set y-axis to weeks, set x-axis to age. Select least squares line from the Measure menu.
What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?

Interpret Data

I performed a linear regression on a sample of animals at the shelter [dataset or subset] and found a moderate (R=.448), positive [weak / strong / moderate (R=...), positive / negative] correlation between age [x-axis] and time to adoption [y-axis]. I would predict that a 1 year [x-axis units] increase in age [x-axis] is associated with a .789 week [slope, y-units] increase [increase / decrease] in time to adoption [y-axis].

Ask Questions

What question do you have?

Question Type (circle one):
Lookup
Arithmetic
Statistical

Consider Data

Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.)

What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)

Analyze Data

What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?

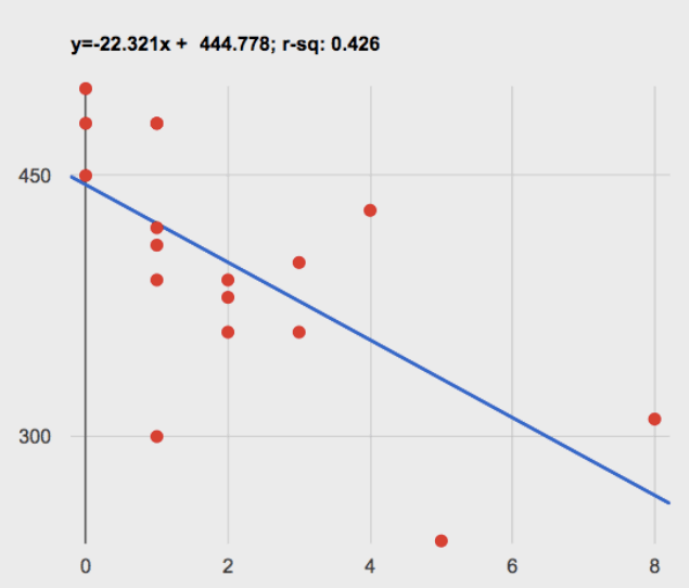
Interpret Data

I performed a linear regression on a sample of _____ [dataset or subset] and found a _____ [weak / strong / moderate (R=...), positive / negative] correlation between _____ [x-axis] and _____ [y-axis]. I would predict that a 1 _____ [x-axis units] increase in _____ [x-axis] is associated with a _____ [slope, y-units] _____ [increase / decrease] in _____ [y-axis].

Describing Relationships

A small sample of people were surveyed about their coffee drinking and sleeping habits. Does drinking coffee impact one's amount of sleep?
NOTE: this data is made up for instructional purposes!

Daily Cups of Coffee	Sleep (minutes)
3	400
0	480
8	310
1	300
1	390
2	360
1	410
0	500
2	390
1	480
3	360
4	430
0	450
5	240
1	420
2	380
1	480



1) Describe the relationship between coffee intake and minutes of sleep shown in the data above.

2) Why is the y-axis of the display above misleading?

Data Cycle: Regression Analysis

Open your chosen dataset. Ask a question about your data to tell your Data Story.

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	I performed a linear regression on a sample of _____ [dataset or subset] and found a _____ [weak / strong / moderate (R=…), positive / negative] correlation between _____ [x-axis] and _____ [y-axis]. I would predict that a 1 _____ [x-axis units] increase in _____ [x-axis] is associated with a _____ [slope, y-units] _____ [increase / decrease] in _____ [y-axis].	

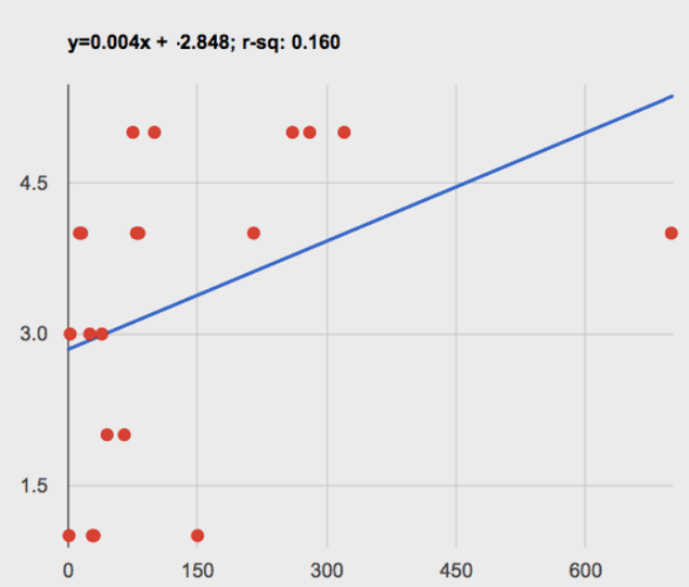
Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic ***Statistical***
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	I performed a linear regression on a sample of _____ [dataset or subset] and found a _____ [weak / strong / moderate (R=…), positive / negative] correlation between _____ [x-axis] and _____ [y-axis]. I would predict that a 1 _____ [x-axis units] increase in _____ [x-axis] is associated with a _____ [slope, y-units] _____ [increase / decrease] in _____ [y-axis].	

Describing Relationships (2)

A small sample of people were surveyed about their satisfaction with their most recent purchase using a scale from 1 (very unsatisfied) to 5 (extremely satisfied).

NOTE: this data is made up for instructional purposes!

Dollars	Satisfaction
15.5	4
280	5
0.99	1
2.3	3
39	3
82	4
215	4
700	4
25	3
79	4
99.99	5
30	1
75	5
13	4
320	5
260	5
150	1
28	1
45	2
65	2



Describe the relationship between dollars spent and satisfaction shown in the data above.

Data Cycle: Regression Analysis 2

Open your chosen dataset. Ask a question about your data to tell your Data Story.

Ask Questions 	What question do you have?	**Question Type** (circle one): Lookup Arithmetic Statistical
Consider Data 	Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.) What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)	
Analyze Data 	If you only need some rows, write an expression for your Filter Transformer here. If you need to Transform or Build an attribute, write the expression for your Transformer here. What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?	
Interpret Data 	What did you find out? What can you infer? What - if any - new question(s) does this raise?	

Write your Data Story below:

I performed a linear regression on a sample of _____ (dataset or subset) and found

_____ (a weak/strong/moderate (R=…), positive/negative) correlation between

_____ (x-axis) and

_____ (y-axis). I would predict that a 1 _____ (x-axis units) increase in

_____ (x-axis) is associated with a _____ (slope, y-units) _____ (increase/decrease) in

_____ (y-axis).

Case Study: Ethics, Privacy, and Bias

These questions are designed to accompany one of the case studies provided in the Ethics, Privacy, and Bias lesson.

My Case Study is _____

1) Read the case study you were assigned, and write your summary here.

_____

_____

_____

_____

_____

2) Is this a good thing or a bad thing? Why?

_____

_____

_____

_____

_____

3) What are the arguments on *each* side?
Data Science used for this purpose is good because…

_____

_____

_____

_____

_____

Data Science used for this purpose is bad because…

_____

_____

_____

_____

_____

Collecting Data

"In a survey of three hundred thousand people, the average height was less than four feet tall"

Politicians pass laws, shoppers choose brands, and countries go to war based on studies that sounds reliable. But is everything that *seems* reliable actually reliable? **Can we really trust these studies?**

There are many ways for a study to be flawed. Some flaws sneak in by accident, and data scientists have an obligation to look for these flaws and minimize them.

- A survey of people's favorite restaurants will be flawed, if it's only given to vegetarians.
- Some people might not fill out a survey that requires them to share their religion. This might change the results of the survey!
- A survey that lets people write whatever they want for "sex" might get some answers that are left blank, misspelled, or answers that aren't really about sex. Removing these responses from the dataset might change the results of the survey - especially if a certain group is more likely to leave it blank.

Being an ethical data scientist means making sure that every element of your study is designed to minimize bias in the data and the analysis.

Analyzing Survey Results When Data is Dirty

These questions are designed to accompany the Survey of Eighth Graders and their Favorite Desserts Starter File.

1) Paolo made a `dot plot` of the `dessert` column and was suprised to discover that **Fruit** was the most popular dessert among 8th graders! Make the `dot plot`. Why is this display misleading? How is the data "dirty"?

2) What ideas do you have for how the survey designer could have made sure that the data in the `dessert` column would have been cleaner?

3) Shani made a `bar-chart` of the `gender-id` column. In her analysis she stated that the most common gender identity among eighth graders in her class is male. Make the `bar-chart`. Do you agree? Why or Why Not?

4) Make a chart showing the ages of the 8th graders surveyed. What "dirty" data problems do you spot and how are they misleading?

5) What ideas do you have for how the survey designer could have made sure that the data in the `age` column would have been cleaner?

Dirty Data!

Open the New Animals Dataset and take a careful look. A bunch of new animals are coming to the shelter, and that means more data!

What do you Notice?	What do you Wonder?

There are many different ways that data can be dirty!

1. **Missing Data** - A column containing some cells with data, but some cells left blank.
2. **Inconsistent Types** - A column with inconsistent data types. For example, a `years` column where almost every cell is a Number, but one cell contains the string `"5 years old"`.
3. **Inconsistent Units** - A column with consistent data types, but inconsistent units. For example, a `weight` column where some entries are in pounds but others are in kilograms.
4. **Inconsistent Naming** - Inconsistent spelling and capitalization for entries lead to them being counted as different. For example, a `species` column where some entries are `"cat"` and others are `"Cat"` will not give us a full picture of the cats.

1) Which animals' row(s) have **missing data**? _____

2) Which column(s) have **inconsistent types**? _____

3) Which column(s) have **inconsistent units**? _____

4) Which column(s) have **inconsistent naming**? _____

5) If we want to analyze this data, what should we do with the rows for Tanner, Toni, and Lizzy? _____

_____

6) If we want to analyze this data, what should we do with the rows for Chanel and Bibbles? _____

_____

7) If we want to analyze this data, what should we do with the rows for Porche and Boss? _____

_____

8) If we want to analyze this data, what should we do with the row for Niko? _____

_____

9) If we want to analyze this data, what should we do with rows for Mona, Rover, Susie Q, and Happy? _____

_____

10) Sometimes data cleaning is straightforward. Sometimes the problem is evident but the solution is less certain. For which questions were you certain of your data cleaning suggestion? For which were you less certain? Why? _____

_____

_____

Bad Questions Make Dirty Data

The **Height v Wingspan Survey** has *lots* of problems, which can lead to many kinds of dirty data: Missing Data, Inconsistent Types, Inconsistent Units and Inconsistent Language! Using the link provided by your teacher to your class' copy of the survey, try filling it out with bad data. Record the problems and make some recommendations for how to improve the survey!

Q	What examples of bad data were you able to submit?	How could the survey be improved to avoid bad data?
A		
B		
C		
D		

Filter and Booleans

A **Boolean** is a type of data with two values: true and false.

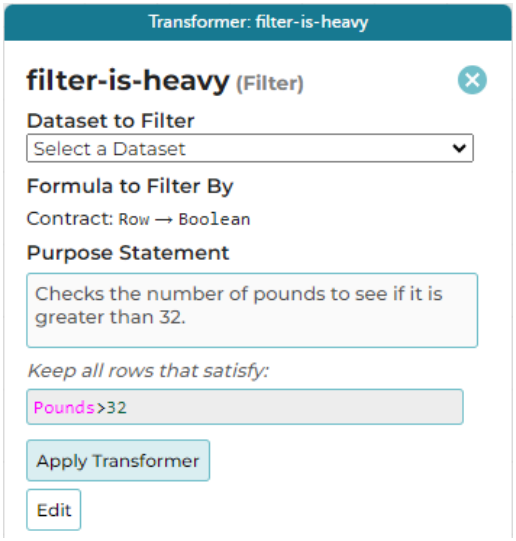
Transformers allow us to transform datasets to produce new, distinct output datasets, instead of modifying the original input dataset itself. We use them to manipulate tables and enable low-stakes "what if?" exploration.

We must provide the `Filter` Transformer with a Boolean expression, which evaluates to true or false. `Filter` then produces a copy of the input dataset that only has the cases for which the expression evaluated to true.

Every Transformer we make requires a unique expression. It's important to get the expression just right, or the Transformer will produce an error. Strings belong inside quotation marks, but Booleans do not!

Booleans and Filters (1)

Notice & Wonder



1) What do you Notice about the `Filter` Transformer on the left, which you can also view in the Boolean Starter File?

2) What do you Wonder about the `Filter` Transformer?

3) In the Boolean Starter File, open `filter-is-heavy`. (To do so, select the – that appears on the left when you hover.) Select "Apply Transformer". In your own words, describe what happened when you applied the Filter transformer to the Animals Dataset. _____

Some Booleans You Might Know

In the `filter-is-heavy` Transformer (above), we used a *Boolean* expression to tell CODAP that we wanted to keep all rows where Pounds was greater than 32. The *greater than* symbol (>) is an example of a Boolean operator that you're probably already familiar with.

4) Here are six different Booleans that we will use in CODAP.

- Put a check mark by the Booleans where you can guess what they do.
- Put a question mark by any Booleans that you're not sure about.

>	<	=	>=	>=	!=

Boolean-producing expressions are yes-or-no questions and will always evaluate to either `true` ("yes") or `false` ("no"). What will each of the expressions below evaluate to? Write down your prediction in the space provided. You'll get a chance to see if you were correct on the next page.

5) `3 <= 4` _____

6) `"a" > "b"` _____

7) `3 = 2` _____

8) `"a" < "b"` _____

9) `2 < 4` _____

10) `"a" = "b"` _____

11) `5 >= 5` _____

12) `"a" != "a"` _____

13) `4 >= 6` _____

14) `"a" >= "a"` _____

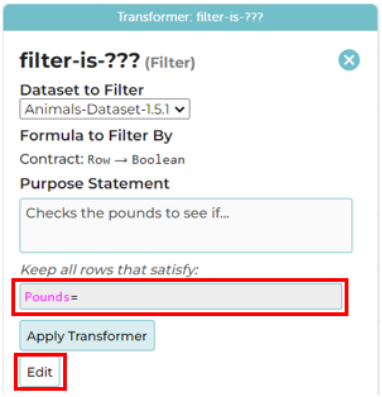
15) `3 != 3` _____

16) `"a" != "b"` _____

Booleans and Filters (2)

Booleans and Numbers

In the Boolean Starter File, open the Transformer called `filter-is-???`, pictured below. For each prompt below, you will select "Edit" in the Transformer, and then enter the specified Boolean expression. (Relevant boxes are highlighted in red in the image on the right.)



1) Click Edit. Change `Pounds=` so that it says `Pounds=32`. What happened? _____

_____

2) What would be a good **name** for a Transformer with the expression `Pounds=32`?

_____

3) What would be a good Purpose Statement for a Transformer with the expression `Pounds=32`?

_____

4) With your partner, test out each of the Booleans listed below, using `Pounds` _____ `32` as the Transformer's expression.

- What happens if you put < in the blank? _____
- What happens if you put > in the blank? _____
- What happens if you put < = in the blank? _____
- What happens if you put > = in the blank? _____
- What happens if you put ! = in the blank? _____

Booleans and Strings

5) Click Edit. This time, type `Name>"Maple"` in the expression box. What happened? _____

_____

6) Predict what will happen if you edit the expression so that it says `Name<="Maple"` (then try it!). _____

_____

7) With your partner, test out each of the Booleans listed below, using `Name` _____ `Maple` as the expression.

- What happens if you put < in the blank? _____
- What happens if you put = in the blank? _____
- What happens if you put >= in the blank? _____
- What happens if you put <= in the blank? _____
- What happens if you put != in the blank? _____

8) Edit the Transformer's expression so that it says: `beginsWith(Name, "Sn")`. What happened? _____

_____

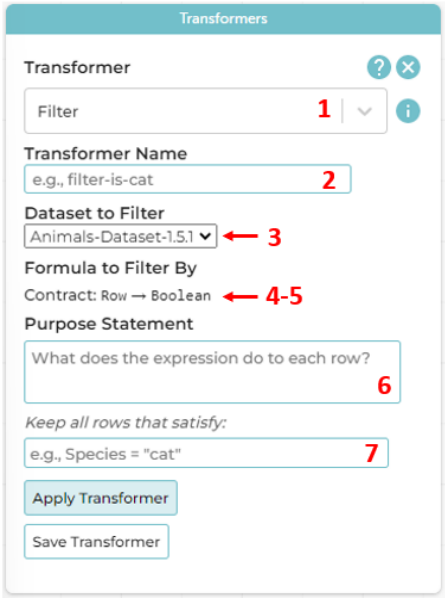
9) Now try this expression: `beginsWith(Name, "sn")`. Did you get the result you expected? _____

★ Go back to Booleans and Filters (1) and use a different color pen to correct any questions (4-15) that you got wrong.

Filter

Make sure you're logged into the Animals Starter File in CODAP. Select the Plugins icon, then choose Transformers.

Create, Apply, and Save a Filter Transformer (Step by Step)



1) Choose Filter from the drop-down menu that appears (Box 1).

2) Name the Transformer `filter-is-dog`. Type the name into Box 2 (left).

3) Click on "Dataset to Filter" to confirm that the Animals Dataset is selected.

4) The Contract's Domain is Row. Why does that makes sense?

_____

5) The Range - is Boolean. Why does that make sense?

_____

6) What Purpose Statement will you type into Box 6?

7) Enter `Species = "dog"` as the expression (Box 7). Select `Apply Transformer`. What happens? _____

_____

8) Try typing `species = "dog"` as the expression (instead of `Species = "dog"`). What happens? _____

_____

9) What are some other possible reasons you might get an error message for the expression? _____

_____

10) Select "Save Transformer." Describe what happens. Why might it be useful to save a Transformer? _____

_____

More Filtering (On Your Own)

11) Create, save, and apply a Transformer called `filter-is-old` that creates a new dataset with animals older than 5 years.

- How many rows does the resulting table have? _____
- How many datasets appeared in the drop-down menu for you to choose from? _____
- Which dataset did you choose and why? _____

12) Create, save, and apply a Transformer called `filter-is-fixed` that creates a new dataset with only fixed animals.

- How many fixed animals are there at the shelter? _____

Writing Purpose Statements & Expressions

Follow your teachers' instructions for completing this page:

- First, write Purpose Statements that describe what the Transformer's expression does. For some scenarios, there are multiple correct responses.
- Then, write down what the Transformer's expression is, using information from your Purpose Statement.

Scenario 1

Original Table

Name	Species
Gila	lizard
Bo	dog
Nibblet	rabbit

Transformed Table

Name	Species
Gila	lizard

- **Purpose Statement:** Checks the row to see whether the _____ is a _____
- **What is this Transformer's expression?** _____

Scenario 2

Original Table

Name	Pounds
Maple	51.6
Bo	76.1
Lucky	45.4

Transformed Table

Name	Pounds
Lucky	45.4

- **Purpose Statement:** _____
- **What is this Transformer's expression?** _____

Scenario 3

Original Table

Name	Sex
Sasha	female
Felix	male
Sheba	female

Transformed Table

Name	Sex
Sasha	female
Sheba	female

- **Purpose Statement:** _____
- **What is this Transformer's expression?** _____

Writing Examples from Purpose Statements

Read the provided Purpose Statement, then fill in the original table and the transformed table with examples from the Animals Starter File that reflect each transformation. Answers will vary.

1) **Purpose Statement:** Checks the row to see if the species is a dog.

Original Table		Transformed Table	
Name		Name	

2) **Purpose Statement:** Checks the row to see if age is greater than 6 years.

Original Table		Transformed Table	
Name		Name	

3) **Purpose Statement:** Checks the row to see if age is less than or equal to 6 years.

Original Table		Transformed Table	
Name		Name	

4) **Purpose Statement:** Checks the row to see if legs is **not** equal to four.

Original Table		Transformed Table	
Name		Name	

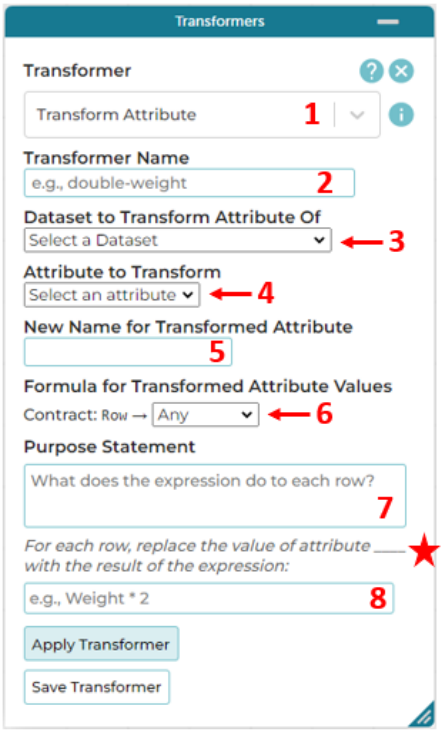
5) **Purpose Statement:** Checks the row to see if the animal's name is less than 5 letters long.

Original Table		Transformed Table	
Name		Name	

Transform Attribute

Make sure you're logged into the Animals Starter File in CODAP. Select the Plugins icon, then choose Transformers.

Create, Apply, and Save a Transform Attribute Transformer (Step by Step)



1) Choose Transform Attribute from the drop-down menu.

2) We want to create a Transformer that will replace all ages less than 5 with the Boolean `true`. In other words, it will *transform* our "age" column into a column that tells us if an animal is young or not. What is a good name for this Transformer?

_____

3) Select the dataset you'd like to transform.

4) What attribute will we be transforming? _____

★ Select the attribute. Notice that CODAP replaced the blank in the starred line of text (left) with the attribute name you selected!

5) What would be an appropriate name for our transformed attribute? _____

6) The Contract includes a Domain (row) only. What is the Range? _____

7) Let's write a Purpose Statement: *Checks each* _____ *to see if* _____

8) What is the expression? _____

9) Apply, the Transformer, and then Save it.

More Transforming (On Your Own)

Create a Transformer called `transform-pounds-kg`. (Note: To convert pounds to kilograms, divide pounds by 2.205.)

10) How many kilograms is the heaviest animal in the shelter? *Hint: If you want to see the animals listed in order by weight, select the attribute name and select "Sort Ascending."*

_____

Create a Transformer called `transform-pounds-round` that uses this expression: `round(Pounds)`.

11) What do you think the `round` function does? _____

_____

Create a Transformer called `transform-Name+Species` that transforms Name using this expression: `concat(Name, Species)`. Let's call the Transformed Attribute `Name+Species`.

Write a Purpose Statement that describes what this expression does to each row. _____

_____

Create a Transformer to change the number of weeks to adoption to instead show the number of days to adoption.

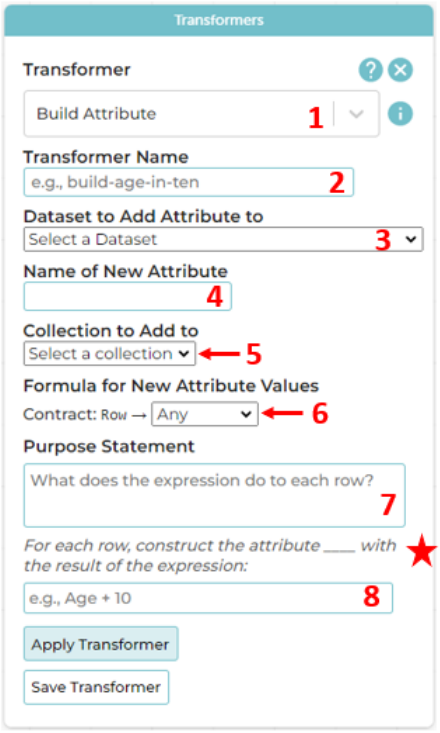
12) What is your Purpose Statement? _____

13) What expression will you use? _____

Build Attribute

Make sure you're logged into the Animals Starter File in CODAP. Select the Plugins icon, then choose Transformers.

Create, Apply, and Save a Build Attribute Transformer (Step by Step)



1) Choose Build Attribute from the drop-down menu (Box 1).

2) At the shelter, animals are considered heavy when they weigh more than 40 pounds. Enter `build-is-heavy` as the Transformer Name (Box 2). What does this name tell you about the Transformer we are creating?

_____

3) Select the dataset you'd like to transform (Box 3).

4) Let's name our new attribute `Heavy` (Box 4). What happened to the starred text (left) when you named the attribute?

_____

5) Ensure that the collection you are adding to is "cases" (Box 5).

6) A domain is provided (row), but not a range. What is the desired output for `build-is-heavy`? _____

7) Write a purpose statement (Box 7). What do we want the expression to do?

_____

8) Enter `Pounds > 40` as the expression (Box 8).

9) Apply the Transformer. To define the Transformer for future use, select `Save`.

More Building (On Your Own)

Create a Transformer called `build-updated-age`, which will give the animals' ages one year from today.

10) How many animals are 9 years-old one year from today? _____

Create a Transformer that builds a column with the number of letters in each animal's name.

11) What did you name your Transformer and the new attribute? _____

12) How many animals have exactly 8 letters in their names? (Feeling adventurous? Try using the `Count` Transformer here!) _____

Create a Transformer to build a column that returns `true` if the number of letters in an animal's name (the column you created in Question 11!) is less than or equal to five.

Note: Does your new attribute name have a space or a hyphen? If so, CODAP will produce an error when you apply your Transformer. Either change the name of the attribute or wrap your entire attribute name inside tick marks (`) when you type in your expression. (The tick mark key is in the upper left-hand corner of your keyboard.)

13) What expression will you use? _____

14) Which dataset will you need to apply this Transformer to? Why? _____

_____

Create Transformer Cards

The table `t` below represents three animals from the shelter:

name	sex	age	fixed	pounds
`"Toggle"`	`"female"`	`3`	`true`	`48`
`"Fritz"`	`"male"`	`4`	`true`	`92`
`"Nori"`	`"female"`	`6`	`true`	`35.3`

Create a Transformer card that responds to the given prompt on the left. When you're done, give the Transformer a useful name. We've done the first one to get you started.

	Prompt	Transformer Card	Name & Purpose Statement
1	Create a Transformer that produces a Table containing all animals younger than 5.	**Type:** filter [filter/build/transform] **Dataset:** `t` **Expression:** `age<5`	`filter-if-young` Checks the row to see whether age is less than 5.
2	Create a Transformer that produces a Table showing all fixed animals.	**Type:** _____ [filter/build/transform] **Dataset:** _____ **Expression:** _____	
3	Create a Transformer that produces a Table with a new column ("age next year") that adds 1 year to each age.	**Type:** _____ [filter/build/transform] **Dataset:** _____ **Name of New Attribute:** _____ **Expression:** _____	
4	Create a Transformer that produces a Table that transforms pounds to kilos (divide by 2.205) but does **not** add a new column.	**Type:** _____ [filter/build/transform] **Dataset:** _____ **Attribute to Transform:** _____ **Name of New Attribute:** _____ **Expression:** _____	
5	Create a Transformer that produces a Table that doubles pounds but does **not** add a new column.	**Type:** _____ [filter/build/transform] **Dataset:** _____ **Attribute to Transform:** _____ **Name of New Attribute:** _____ **Expression:** _____	

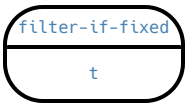
Matching Composed Transformers

The table `t` below represents four animals from the shelter:

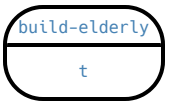
name	sex	age	fixed	pounds
`"Toggle"`	`"female"`	`3`	`true`	`48`
`"Fritz"`	`"male"`	`4`	`true`	`92`
`"Nori"`	`"female"`	`6`	`true`	`35.3`
`"Maple"`	`"female"`	`3`	`true`	`51.6`

Match each Circle of Evaluation (left) to the description of what it does (right).

1



2



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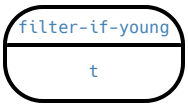

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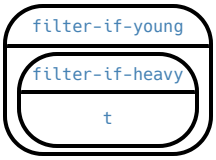

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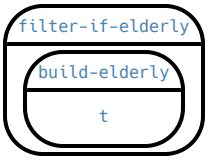

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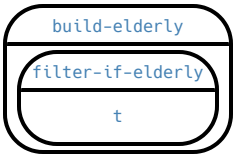


8

A Produces a table containing only Toggle and Maple

B Produces a table with only Maple

C Produces a table that no longer has an "age" column

D Produces a table with an extra column, named "elderly"

E Produces an empty table

F Produces a table containing the same four animals

G Won't run: will produce an error (if so, why?)

H Produces a table with only Nori

Planning Transformer Composition

The table `t` below represents four animals from the shelter:

name	sex	age	fixed	*pounds*
`"Toggle"`	`"female"`	3	`true`	*48*
`"Fritz"`	`"male"`	4	`true`	*92*
`"Nori"`	`"female"`	6	`true`	*35.3*
`"Sasha"`	`"female"`	1	`false`	*6.5*

You have several Transformers already defined:

filter-if-young filters out animals younger than 4	**filter-if-female** filters out animals that are female	**filter-if-heavy** filters out animals whose weight is greater than 20 kilos	**build-kilos** builds a new column that converts pounds to kilos	**transform-kilos** transforms kilos to grams

For each prompt on the left, draw the Circle of Evaluation that will produce the desired table or display.

	Prompt	Circle of Evaluation
1	Produce a Table containing all young, fixed animals	
2	Produce a Table showing all animals that weigh more than 20 kilograms	
3	Produce a Table showing all female animals that weigh more than 20 kilograms	
4	Produce a Table that provides all animals' weights in grams	
5	Produce a Table for all female animals, which includes their weight in grams	

Transformer Cards to Cut Out

Provide the information needed to define each Transformer. Refer to the table of animals on Create Transformer Cards as needed.

`transform-age` produces a table that transforms `age` to `age-last-year`

Type: _____

Dataset: _____

Attribute to Transform: _____

Name of New Attribute: _____

Expression: _____

`filter-if-fixed` produces a table with only fixed animals

Type: _____

Dataset: _____

Expression: _____

`filter-if-heavy` produces a table with animals that weigh more than 50 pounds

Type: _____

Dataset: _____

Expression: _____

`filter-if-young` produces a table with only animals that are younger than 5

Type: _____

Dataset: _____

Expression: _____

`build-elderly` produces a table with an extra column named `elderly` that indicates if an animal is older than 5

Type: _____

Dataset: _____

Name of New Attribute: _____

Expression: _____

`filter-if-elderly` produces a table that only animals where `elderly = true`

Type: _____

Dataset: _____

Expression: _____

`transform-weight-loss` produces a table where `pounds` becomes `lighter-weight`, which indicates weight after losing 5 pounds

Type: _____

Dataset: _____

Attribute to Transform: _____

Name of New Attribute: _____

Expression: _____

`filter-if-lightest` produces a table with only animals' whose `lighter-weight` is below 30 pounds.

Type: _____

Dataset: _____

Expression: _____

Grouped Samples from the Animals Dataset

You've already created and saved the following transformers: `filter-is-old`, `filter-is-young`, `filter-is-cat`, `filter-is-dog`, `filter-is-female`, `filter-is-fixed`, and `filter-has-s-name`. Provide the transformers you would use in the order you would use them. We've given you the solution for the first sample, to get you started.

	Subset	List the transformers *in order*	Use function notation
1	Kittens	`filter-is-young`, `filter-is-cat`	filter-is-young(filter-is-cat(animals-table))
2	Puppies		
3	Fixed Cats		
4	Cats with "s" in their name		
5	Old Dogs		
6	Fixed Animals		
7	Old Female Cats		
8	Fixed Kittens		
9	Fixed Female Dogs		
10	Old Fixed Female Cats		

Displaying Data

Fill in the tables below, then use CODAP to make the following displays. The first table has been filled in for you.

1) A `bar-chart` showing how many puppies are fixed or not.

What Rows?	Which Column(s)?	What will you Create?
puppies	*fixed*	*bar-chart*

2) A `pie-chart` showing how many heavy dogs are fixed or not.

What Rows?	Which Column(s)?	What will you Create?

3) A `histogram` of the number of `weeks` it takes for a random sample of animals to be adopted.

What Rows?	Which Column(s)?	What will you Create?

4) A `box-plot` of the number of `pounds` that kittens weigh.

What Rows?	Which Column(s)?	What will you Create?

5) A `scatter-plot` of a random sample using `species` as the labels, `age` as the x-axis, and `weeks` as the y-axis.

What Rows?	Which Column(s)?	What will you Create?

6) Describe **your own grouped sample** here, and fill in the table below.

What Rows?	Which Column(s)?	What will you Create?

Data Cycle: Analyzing Categorical Data

Use the Animals Starter File to analyze categorical data with the data cycle.

Ask Questions

How many of each species are fixed at the shelter?
What question do you have?

Question Type (circle one):
Lookup
Arithmetic
Statistical

Consider Data

Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.)

What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)

Analyze Data

If you only need some rows, write an expression for your Filter Transformer here.

If you need to Transform or Build an attribute, write the expression for your Transformer here.

What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?

Interpret Data

What did you find out? What can you infer?

What - if any - new question(s) does this raise?

Ask Questions

Are there more female cats than male cats at the shelter?
What question do you have?

Question Type (circle one):
Lookup
Arithmetic
Statistical

Consider Data

Which Rows should we investigate? (All the rows, just the cats, fixed dogs, etc.)

What Column(s) do we need? (age, weight-in-kilograms, weeks, etc.)

Analyze Data

If you only need some rows, write an expression for your Filter Transformer here.

If you need to Transform or Build an attribute, write the expression for your Transformer here.

What display, measure, or table do you want to create (i.e., median, bar chart, scatterplot, etc.)?

Interpret Data

What did you find out? What can you infer?

What - if any - new question(s) does this raise?

Threats to Validity

Threats to Validity can undermine a conclusion, even if the analysis was done correctly.

Some examples of threats are:

- **Selection bias** - identifying the favorite food of the rabbits won't tell us anything reliable about what all the animals eat.
- **Study bias** - If someone is supposed to assess how much cat food is eaten each day on average, but they only measure how much cat food is put in the bowls (instead of how much is actually consumed), they'll end up with an over-estimate.
- **Poor choice of summary** - Suppose a different shelter that had 10 animals recorded adoption times (in weeks) as 1, 1, 1, 7, 7, 8, 8, 9, 9, 10. Using the mode (1) to report what's typical would make it seem like the animals were adopted more quickly than they really were, since 7 out of 10 animals took at least 7 weeks to be adopted.
- **Confounding variables** - Some shelter workers might prefer cats, and steer people towards cats as a result. This would make it appear that "cats are more popular with people", when the real variable dominating the sample is what *workers at the shelter* prefer.

Identifying Threats to Validity

Some volunteers from the animal shelter surveyed a group of pet owners at a local dog park. They found that almost all of the owners were there with their dogs. From this survey, they concluded that dogs are the most popular pet in the state.

What are some possible threats to the validity of this conclusion?

The animal shelter noticed a large increase in pet adoptions between Christmas and Valentine's Day. They conclude that at the current rate, there will be a huge demand for pets this spring.

What are some possible threats to the validity of this conclusion?

Identifying Threats to Validity (2)

The animal shelter wanted to find out what kind of food to buy for their animals. They took a random sample of two animals and the food they eat, and they found that spider and rabbit food was by far the most popular cuisine!

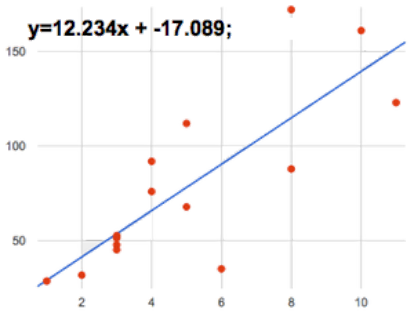
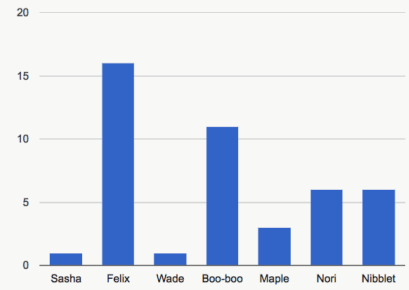
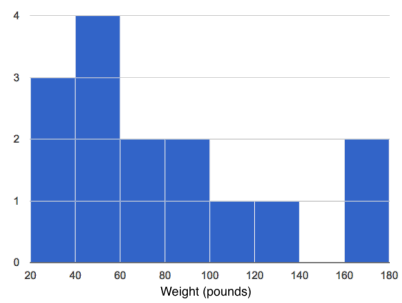
Explain why sampling just two animals can result in unreliable conclusions about what kind of food is needed.

A volunteer opens the shelter in the morning and walks all the dogs. At mid-day, another volunteer feeds all the dogs and walks them again. In the evening, a third volunteer walks the dogs a final time and closes the shelter. The volunteers report that the dogs are much friendlier and more active at mid-day, so the shelter staff assume the second volunteer must be better with animals than the others.

What are some possible threats to the validity of this conclusion?

Fake News

There are six separate, *unrelated* claims below, and ALL OF THEM ARE WRONG! Your job is to figure out why by looking at the data.

	Data	Claim	What's Wrong
1	The average player on a basketball team is 6'1".	*"Most of the players are taller than 6'."*	
2	Linear regression found a positive correlation (r=0.42) between people's height and salary.	*"Taller people are more qualified for their jobs."*	
3		*"According to the predictor function indicated here, the value on the x-axis will predict the value on the y-axis 63.6% of the time."*	
4		*"According to this bar chart, Felix makes up a little more than 15% of the total ages of all the animals in the dataset."*	
5		*"According to this histogram, most animals weigh between 40 and 60 pounds."*	
6	Linear regression found a negative correlation (r= -0.91) between the number of hairs on a person's head and their likelihood of owning a wig.	*"Owning wigs causes people to go bald."*	

Lies, Darned Lies, and Statistics

1) Using real data and displays from your dataset, come up with a misleading claim.

Data	Claim	Why it's wrong

2) Trade papers with someone and figure out why their claims are wrong!

Selection Bias or Biased Study?

The school newspaper ran an article stating that chicken was more popular than pork in the East Village.

Kendell thinks the study was biased.

Would you rather eat pork or delicious crispy fried chicken? That's such a leading question! It encouraged people to pick chicken. I bet the results would have been different if they had asked about crispy bacon!

Carson thinks the study suffered from selection bias.

One of the survey sites was outside of a mosque?! Muslims don't even eat pork!

Who's right? How do you know?

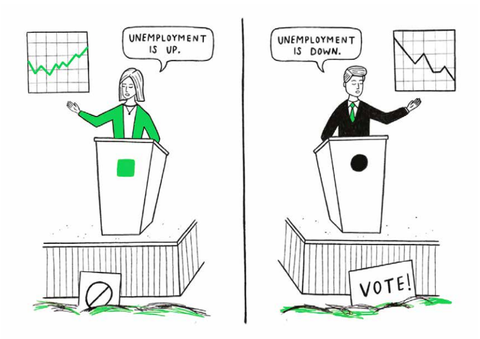
Identifying Threats to Validity (3)

Data scientists want to know if listening to music or podcasts reduces symptoms of stress in individuals.

- They conducted **a study of 1,000 people who were brought into a laboratory office for testing**.
- While wearing a heart-rate monitor, participants were asked to listen to either music or a podcast of their choosing while completing a series of complicated puzzles.
- The data scientists discovered that on average, **participants who listened to music had a 5% lower heart rate while completing the tasks than those who listened topodcasts**.

Before publishing their findings, the data scientists have asked you to review their claim. In the space below, indicate possible **threats to validity** faced by this study.

Data Fallacies to Avoid

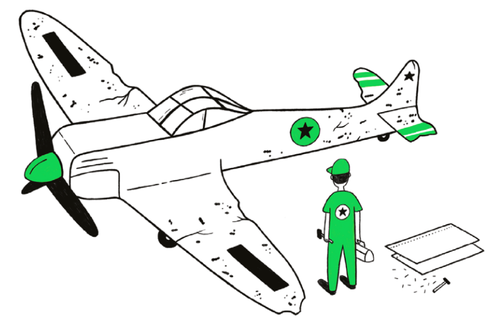


Cherry Picking

Selecting results that fit your claim and excluding those that don't.

Data Dredging

Repeatedly testing new hypotheses against the same set of data, failing to acknowledge that most correlations will be the result of chance.

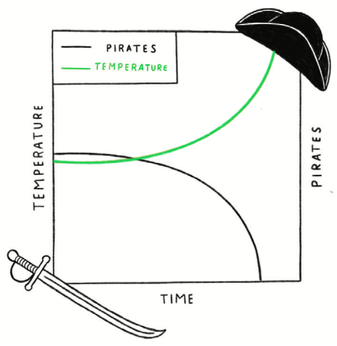


Survivorship Bias

Drawing conclusions from an incomplete set of data, because that data has 'survived' some selection criteria.

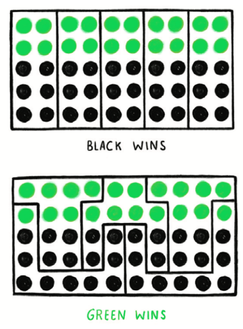
Cobra Effect

Setting an incentive that accidentally produces the opposite result to the one intended. Also known as a Perverse Incentive.



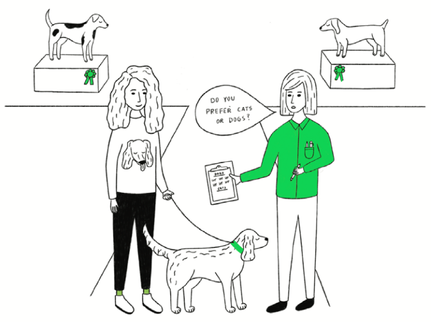
False Causality

Falsely assuming when two events appear related that one must have caused the other.



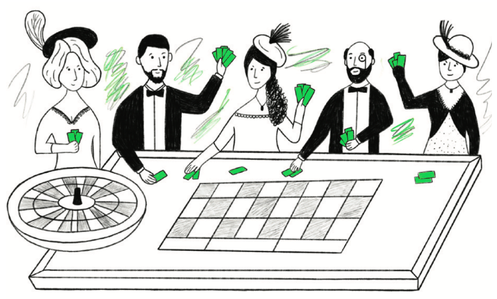
Gerrymandering

Manipulating the geographical boundaries used to group data in order to change the result.



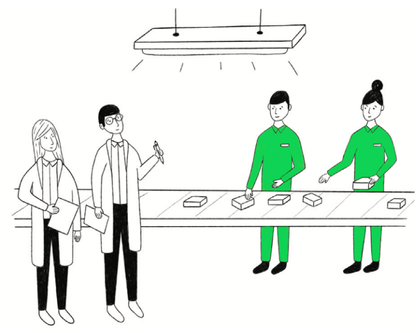
Sampling Bias

Drawing conclusions from a set of data that isn't representative of the population you're trying to understand.



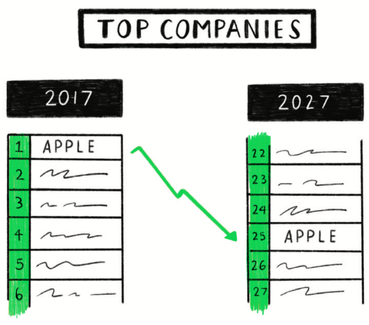
Gambler's Fallacy

Mistakenly believing that because something has happened more frequently than usual, it's now less likely to happen in future (and vice versa).



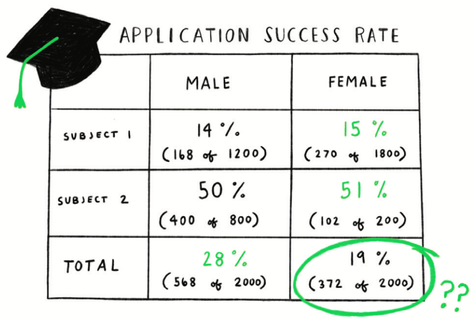
Hawthorne Effect

The act of monitoring someone can affect their behaviour, leading to spurious findings. Also known as the Observer Effect.



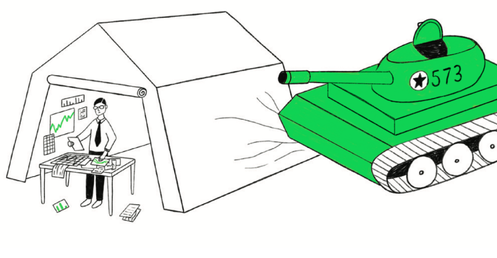
Regression Towards the Mean

When something happens that's unusually good or bad, it will revert back towards the average over time.



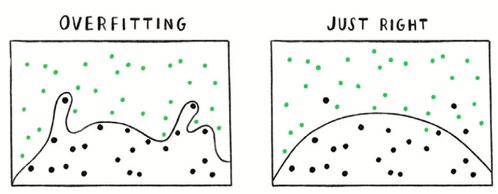
Simpson's Paradox

When a trend appears in different subsets of data but disappears or reverses when the groups are combined.



McNamara Fallacy

Relying solely on metrics in complex situations and losing sight of the bigger picture.

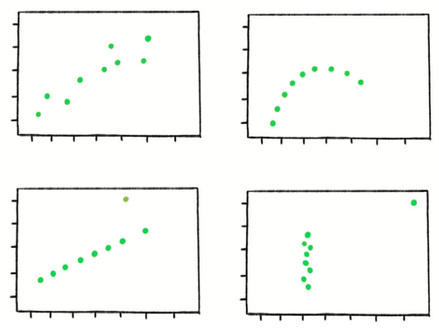


Overfitting

Creating a model that's overly tailored to the data you have and not representative of the general trend.

Publication Bias

Interesting research findings are more likely to be published, distorting our impression of reality.



Danger of Summary Metrics

Only looking at summary metrics and missing big differences in the raw data.

geckoboard

Read more at
geckoboard.com/data-fallacies

Threats to Validity Rubric

	Wow!	Getting There	Needs Improvement
Selection bias	The research plan lays out clearly and specifically how information will be gathered from a non-representative sample of the population.	The research plan lays out how information will be gathered from a non-representative sample of the population, but is lacking in detail and specificity.	The research plan does not address how information will be gathered from a non-representative sample of the population.
Bias in the study design	The study is clearly biased, with "loaded" questions that lead to misrepresentation of true opinions.	The study includes some bias, but it is unclear how the plan will lead to misrepresentation of true opinions.	The study design does not include bias.
Poor choice of summary data	The research plan includes extreme outliers that will shift the results of the analysis in ways that do not represent the population as a whole.	The research plan includes some outliers, but they are perhaps not adequately extreme to shift the results and misrepresent the population.	The research plan does not include extreme outliers.
Confounding variables	The study overlooks factors that clearly influence a relationship, leading to invalid claims.	The study overlooks factors that might influence a relationship, perhaps leading to invalid claims.	The study does not include any confounding variables.
Discuss Conclusions	The concluding discussion clearly articulates how all of the threats to validity cause problems to the study's conclusions.	The concluding discussion only articulates how some of the threats caused problems or is lacking in detail and evidence / analysis.	The concluding discussion is lacking in detail and evidence. Understanding of how threats to validity influence a study is not demonstrated.
Good Data Scientists would…	Clear explanations are provided of what changes could be made to minimize the threats.	Some explanation is provided of what changes could be made to minimize threats, but more details are needed.	Understanding of how to revise the study to minimize threats is not demonstrated.

Our Research Plan

With your partner, respond to the prompts below. Note: You can consider this page a rough draft of the final project that you will eventually produce.

1) Our statistical question:

2) Our research plan in brief:

3) How we will incorporate **selection bias** :

4) How we will incorporate **bias in the study design** :

5) How we will incorporate **poor choice of summary data** :

6) How we will incorporate **confounding variables** :

Major Threats to Validitiy

- **Selection Bias** - Data was gathered from a biased sample of the population. This is the problem with surveying cat owners to find out which animal is most loved!
- **Bias in the Study Design** - Data was gathered using a "loaded" question like "Since annual vet care comes to about $300 for dogs and only about half of that for cats, would you say that owning a cat is less of a burden than owning a dog?" This could easily lead to a misrepresentation of people's true opinions.
- **Poor Choice of Summary Data** - Even if the selection is unbiased, sometimes outliers are so extreme that they make the mean completely useless at best - and misleading at worst.
- **Confounding Variables** - A study might find that cat owners are more likely to use public transportation than dog owners. But it's not that owning a cat means you drive less: people who live in big cities are more likely to use public transportation, and also more likely to own cats. More examples of confounding variables can be found in the correlations lesson: Correlation Does Not Imply Causation!.

Analysis of Research Plan Predicted Outcomes

Respond to the prompts below with your partner.

1) How will the validity of your conclusions be impacted by **Selection Bias**?

2) What would a good data scientist change to minimize **Selection Bias**?

3) How will the validity of your conclusions be impacted by **Bias in the Study Design**?

4) What would a good data scientist change to minimize **Bias in the Study Design**?

5) How will the validity of your conclusions be impacted by **Poor Choice of Summary Data**?

6) What would a good data scientist change to minimize **Poor Choice of Summary Data**?

7) How will the validity of your conclusions be impacted by **Confounding Variables**?

8) What would a good data scientist change to minimize **Confounding Variables**?

Rubric: Research Project 1

About this Dataset

Wow!	Getting There	Needs Improvement
I explained why this dataset is interesting to me, others like me, and why others should care about this data. I considered why the dataset was collected, and what purpose it might serve. I correctly identified all the rows, columns, and types in my dataset.	I explained why this dataset was interesting to me and at least one other person/group, and shared *something* about where it came from. I correctly identified most of the rows, columns, and types in my dataset.	I explained why this dataset was interesting to me, and shared *something* about where it came from. I correctly identified some rows, columns, and types in my dataset.

My Questions

Wow!	Getting There	Needs Improvement
I had lots of questions by the end of the exploration, and I chose at least two that I thought were most interesting. I explained why I thought they were interesting, and wrote about grouped samples that might be good to explore when answering those questions.	I had a few questions by the end of the exploration, and I chose at least one that was interesting. I wrote about grouped samples that might be good to explore.	I picked a question, and wrote about grouped samples.

Analysis: Quantity, Variety, and Connectedness of Displays

Wow!	Getting There	Needs Improvement
I used a variety of categorical and quantitative displays, including at least 10 different displays in my project. I gave each display a descriptive title. I specified how the display changed my thinking and influenced the next display that I chose to make.	Throughout my project, I used a limited assortment of displays. I included at least 8 different displays in my project. Most of my displays were descriptively titled. I attempted to describe how the display changed my thinking and influenced the next display that I made - but my descriptions were unclear.	I included 4 or fewer displays in my project. The displays did not include titles, or the titles were not descriptive. I did not adequately describe how each display changed my thinking.

Discussion: Threats to Validity, Ethical Implications, Questions for Future Study

Wow!	Getting There	Needs Improvement
I explained my findings clearly and in detail. I also wrote about possible threats to validity, considering all of the different threats we learned about in the context of diversity, bias, power, and discrimination. I explained why (or why not) the results were enough to make a strong claim. I thought about the ethical implications of collecting this data, or how my research might be used in good or bad ways. I wrote about how I would continue this research, with more data and/or more questions.	I explained my findings, and wrote about some threats to validity and ethical questions. I considered some issues regarding diversity, bias, power and discrimination - but not all of them. I wrote about possible ways to continue the research.	I talked about my findings, but only discussed some threats to validity, ethics, or possible future research. Other parts were missing.

Additional Teacher Feedback

Rubric: Research Project 2

Students :-In the left hand column, record the title of each display you made. Write titles in the order in which they appear in your slide deck. If you need additional copies of this page, ask your teacher.

Analysis :

Wow!	Getting There	Needs Improvement
I interpreted the display accurately and thoughtfully. I explained how the display helps me answer the question I chose to study.	I interpreted the display accurately. I attempted to connect the display to my research question, but that connection was sometimes unclear.	My interpretation of the display is inaccurate. It was unclear how the display connected to or answered my research question.

Display	Rating	Teacher Feedback
	❏ Wow ❏ Getting There ❏ Needs Improvement	
	❏ Wow ❏ Getting There ❏ Needs Improvement	
	❏ Wow ❏ Getting There ❏ Needs Improvement	
	❏ Wow ❏ Getting There ❏ Needs Improvement	
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Design Recipe

Directions:

Transformer (check one) ☐ **Filter** ☐ **Transform** ☐ **Build**

Transformer name

Example Tables

What gets filtered/transformed/built? In the sample tables below, (if needed) add the relevant columns.

Original Table

Transformed Table

Contents (Contract, Purpose Statement, and Expression)

Row ->
Domain Range

Purpose: what does the formula do for each row?

i.e. Weight < 20 or Species = "rabbit". Pay careful attention to capitalization and quotation marks.

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The Animals Dataset

This is a printed version of the animals spreadsheet.

**The numbers on the left side are NOT part of the table!* They are provided to help you identify the index of each row.*

	name	species	sex	age	fixed	legs	pounds	weeks
0	Sasha	cat	female	1	false	4	6.5	3
1	Snuffles	rabbit	female	3	true	4	3.5	8
2	Mittens	cat	female	2	true	4	7.4	1
3	Sunflower	cat	female	5	true	4	8.1	6
4	Felix	cat	male	16	true	4	9.2	5
5	Sheba	cat	female	7	true	4	8.4	6
6	Billie	snail	hermaphrodite	0.5	false	0	0.1	3
7	Snowcone	cat	female	2	true	4	6.5	5
8	Wade	cat	male	1	false	4	3.2	1
9	Hercules	cat	male	3	false	4	13.4	2
10	Toggle	dog	female	3	true	4	48	1
11	Boo-boo	dog	male	11	true	4	123	24
12	Fritz	dog	male	4	true	4	92	3
13	Midnight	dog	female	5	false	4	112	4
14	Rex	dog	male	1	false	4	28.9	9
15	Gir	dog	male	8	false	4	88	5
16	Max	dog	male	3	false	4	52.8	8
17	Nori	dog	female	3	true	4	35.3	1
18	Mr. Peanutbutter	dog	male	10	false	4	161	6
19	Lucky	dog	male	3	true	3	45.4	9
20	Kujo	dog	male	8	false	4	172	30
21	Buddy	lizard	male	2	false	4	0.3	3
22	Gila	lizard	female	3	true	4	1.2	4
23	Bo	dog	male	8	true	4	76.1	10
24	Nibblet	rabbit	male	6	false	4	4.3	2
25	Snuggles	tarantula	female	2	false	8	0.1	1
26	Daisy	dog	female	5	true	4	68	8
27	Ada	dog	female	2	true	4	32	3
28	Miaulis	cat	male	7	false	4	8.8	4
29	Heathcliff	cat	male	1	true	4	2.1	2
30	Tinkles	cat	female	1	true	4	1.7	3
31	Maple	dog	female	3	true	4	51.6	4

Sentence Starters

Use these sentence starters to help describe patterns, make predictions, find comparisons, share discoveries, formulate hypotheses, and ask questions.

Patterns:

- I noticed a pattern when I looked at the data. The pattern is _____
- I see a pattern in the data collected so far. My graph shows _____

Predictions:

- Based on the patterns I see in the data collected so far, I predict that _____
- My prediction for _____ is _____

Comparisons:

- When I compared _____ and _____, I noticed that _____
- The similarities I see between _____ and _____ are _____
- The differences I see between _____ and _____ are _____

Surprises and Discoveries:

- I discovered that _____
- I was surprised by _____
- I noticed something unusual about _____

Hypotheses:

- A possible explanation for what the data showed is _____
- A factor that affected this data might have been _____
- I think this data was affected by _____

Questions:

- I wonder why _____
- I wonder how _____
- How are _____ affected by _____
- How will _____ change if _____

Contracts for Data Science Codap

Contracts tell us how to use a function, by telling us three important things:

1. The **Name**
2. The **Domain** of the function - what kinds of inputs do we need to give the function, and how many?
3. The **Range** of the function - what kind of output will the function give us back?

For example: The contract `triangle :: (Number, String, String) -> Image` tells us that the name of the function is `triangle`, it needs three inputs (a Number and two Strings), and it produces an Image.

With these three pieces of information, we know that typing `triangle(20, "solid", "green")` will evaluate to an Image.

Name	Domain	Range
`# bar-chart`	`::` `( Table (table-name), String (column) )`	`-> Image`
`bar-chart(animals-table, "species")`		
`# bar-chart-summarized`	`::` `( Table (table-name), String (labels), String (values) )`	`-> Image`
`bar-chart-summarized(count(animals-table, "species"), "value","count")`		
`# box-plot`	`::` `( Table (table-name), String (column) )`	`-> Image`
`box-plot(animals-table, "weeks")`		
`# box-plot-scaled`	`::` `( Table (table-name), String (column), Number (low), Number (high) )`	`-> Image`
`box-plot-scaled(animals-table, "weeks", 1, 40)`		
`# histogram`	`::` `( Table (table-name), String (labels), String (values), Number (bin-size) )`	`-> Image`
`histogram(animals-table, "species", "weeks", 2)`		
`# line-graph`	`::` `( Table (table-name), String (labels), String (xs), String (ys) )`	`-> Image`
`line-graph(animals-table, "name", "pounds","weeks")`		
`# lr-plot`	`::` `( Table (table-name), String (labels), String (xs), String (ys) )`	`-> Image`
`lr-plot(animals-table, "name", "pounds","weeks")`		
`# mean`	`::` `( Table (table-name), String (column) )`	`-> Number`
`mean(animals-table, "pounds")`		
`# median`	`::` `( Table (table-name), String (column) )`	`-> Number`
`median(animals-table, "pounds")`		
`# modes`	`::` `( Table (table-name), String (column) )`	`-> List`
`modes(animals-table, "pounds")`		
`# modified-box-plot`	`::` `( Table (table-name), String (column) )`	`-> Image`
`modified-box-plot(animals-table, "pounds")`		

Name	Domain	Range
# modified-box-plot-scaled ::	(Table (table-name), String (column), Number (low), Number (high)) ->	Image
modified-box-plot-scaled(animals-table, "weeks", 1, 40)		
# modified-vert-box-plot ::	(Table (table-name), String (column)) ->	Image
modified-vert-box-plot(animals-table, "pounds")		
# modified-vert-box-plot-scaled ::	(Table (table-name), String (column), Number (low), Number (high)) ->	Image
modified-vert-box-plot-scaled(animals-table, "weeks", 1, 40)		
# pie-chart ::	(Table (table-name), String (column)) ->	Image
pie-chart(animals-table, "species")		
# pie-chart-summarized ::	(Table (table-name), String (labels), String (values)) ->	Image
pie-chart-summarized(count(animals-table, "species"), "value", "count")		
# r-value ::	(Table (table-name), String (xs), String (ys)) ->	Number
r-value(animals-table, "name", "pounds","weeks")		
# random-rows ::	(Table (table-name), Number (num-rows)) ->	Table
random-rows(animals-table, 10) # select 10 random rows from the table		
# scatter-plot ::	(Table (table-name), String (labels), String (xs), String (ys)) ->	Image
scatter-plot(animals-table, "name", "pounds","weeks")		
# stdev ::	(Table (table-name), String (column)) ->	Number
stdev(animals-table, "pounds")		
# vert-box-plot ::	(Table (table-name), String (column)) ->	Image
vert-box-plot(animals-table, "weeks")		
::	->	
::	->	
::	->	
::	->	
::	->	